How to find out about THE CHEMICAL INDUSTRY

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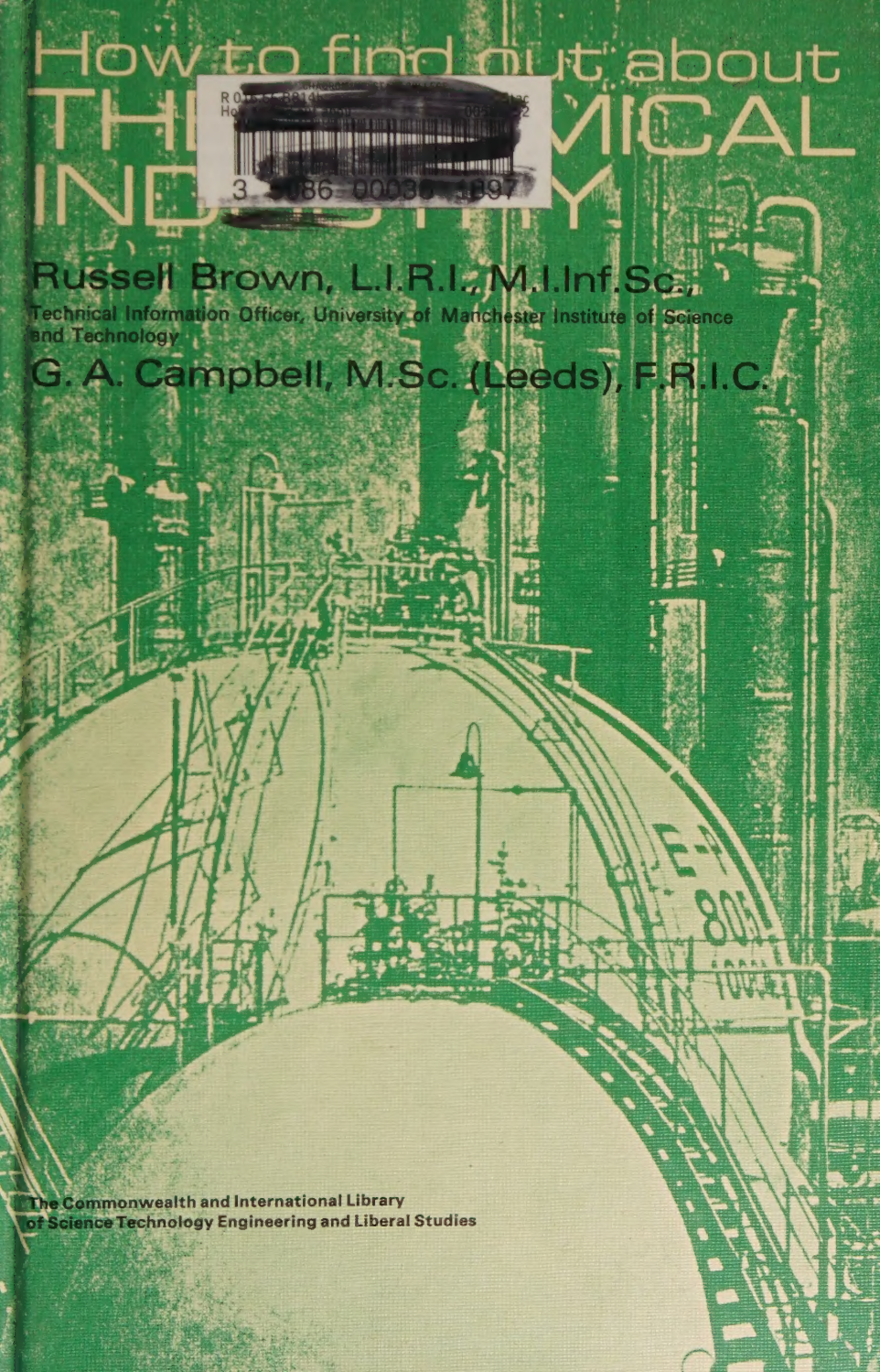

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THE CHEMICAL INDUSTRY

BY

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Contents

LIST OF ILLUSTRATIONS ix

PREFACE xi

1 The Chemical Industry 1

The Early Days 3
The Industrial Revolution 5
Growth of the Industry 8
The Present Structure 10
Dyes and Organic Pigments 12
Pharmaceuticals 13
Pest Control 13
Plastics 14
General 15
Classification of Chemical Products 17
Statistics in the Chemical Industry 20

2 Careers in the Chemical Industry 29

Departments in Chemical Companies 30
Careers 44

3 Qualifications and Training 49

Degree Courses 51
Qualification through the Royal Institute of Chemistry 52
Diploma of Technology 54
National Certificates 54
Laboratory Technicians 55
Chemical Engineers 55
Other Scientific Professional Qualifications 57
Non-technical Qualifications 57
Grants and Scholarships 57

4 Chemical Industry Literature 60

Abstracts 66
Periodicals 67
Guides 75

Directories 76
Films for the Chemical Industry 76
Conferences, Exhibitions, and Trade Fairs 76

5 Organizations 80

Professional Organizations 80
Trade Organizations 83
Employers' Organizations 85
Employees' Organizations 85
Joint Negotiating Machinery 86
Other Organizations 87
Government, Armed Forces, and Nationalized Industries' Organizations 88
Foreign Organizations 91

6 The Specialized Industries 92

S1 Adhesives and Gelatines 93
S2 Detergents and Other Surface-active Agents 94
S3 Disinfectants 96
S4 Dyestuffs 97
S5 Essential Oils, Isolates, Perfumes, and Synthetic Aromatics 100
S6 Explosives 102
S7 Fertilizers 102
S8 Firefighting Agents 105
S9 Fireproofing Agents 106
S10 Foodstuffs Additives 107
S11 Foundry Preparations 109
S12 Fuel and Oil Additives 111
S13 Greases and Lubricants 112
S14 Laboratory Chemicals and Reagents 113
S15 Metal Treatment and Anti-corrosive Products 114
S16 Paints and Surface Coatings 116
S17 Pest Control Products 121
S18 Pharmaceutical Preparations 125
S19 Photographic Chemicals 127
S20 Pigments (a) Coloured, (b) White 128
S21 Plastics 130
S22 Plasticizers 132
S23 Refrigerants and Aerosol Propellants 132
S24 Rubber Chemicals 134
S25 Silicones 136
S26 Soaps 137
S27 Solvents 138
S28 Resins 139
S29 Synthetic Rubber 140
S30 Tanning and Leather Materials 140

S31 Textile and Dyeing Auxiliaries 141
S32 Veterinary Preparations 143
S33 Water-treatment Chemicals 144

7 Patents 146

Why Patents are Important 146
Provisional Patents 147
General Sources of Information about Patents 147
Publications of the British Patent Office 148
Libraries 149
The Main Patent Abstract Journals 149
Reference Works and Textbooks 151
Special Countries 152

8 Research 153

Research in the Chemical Industry 158
Research Information from Libraries 160
Consultants and Sponsored Research Organizations 160
Research Associations 161
Government Research Stations 165
Research in British Universities and Colleges 168
Research by Development Associations 168
Trends in Practical Research 169
Applying the Results of Research 170
Research in Chemical Engineering 170
Costs 170
Government-supported Research and Development 171

9 Safety Measures 174

Sources of Information about Safety 175
Plant Safety Officer 178
Various Hazards 179
Radioactivity 182
Automatic Safety Gear 182
Safety for the User of Chemicals 183
Safety in Chemical Laboratories 184

10 The Computer in the Chemical Industry 185

The Modern Computer 187
The Set-up 189
The Arithmetic Unit 190
Binary Arithmetic 191
The Program 193

The Store 194
Output 195
Data Processing 196
The Computer in the Chemical Industry 198
Careers 200
Other Information 201

INDEX—GENERAL AND ORGANIZATIONS 203

INDEX—BOOK TITLES AND PERIODICALS 211

List of Illustrations

Fig. 1. The Chemical Industry—some typical lines of progress 37

Fig. 2. *Dictionary of Commercial Chemicals* (Snell & Snell) 61

Fig. 3. *Thorpes' Dictionary of Applied Chemistry* 62

Fig. 4. *Kingzett's Chemical Encyclopaedia* 63

Fig. 5. Kirk–Othmer's *Encyclopedia of Chemical Technology* 64

Fig. 6. *The Merck Index* 65

Fig. 7. The *Union List of Serials in Libraries of the United States and Canada*, 3rd edn. 68

Fig. 8. *Dictionary of Chemistry and Chemical Technology in Six Languages* 72–73

Fig. 9. *Chemical Industry Directory and Who's Who* 77

Fig. 10. *British Chemicals and their Manufacturers* 78

Fig. 11. *The Colour Index* 99

Fig. 12. The first British Chemical Patent, dated 1618. 146

Fig. 13. *Chemical Engineers' Handbook* (4th edn.), Perry, Chilton, and Kirkpatrick 154

Fig. 14. *Chemical Engineering Data Book*, Ross and Freshwater 155

Fig. 15. *Encyclopaedia of Science and Technology*, Vol. 11 159

Fig. 16. The basic parts of the computer 189

Preface

THIS is one of a series of books on "How to Find Out". Their purpose is to guide the reader through the various sources of information readily accessible, either by purchase of books or journals, or by reference in the chief libraries.

The first of the series, *How to Find Out* by G. Chandler, M.A., Ph.D., General Editor of the series, deals with knowledge in the widest sense, and is in fact a master guide to the literature of the main branches of science and the arts. Other volumes so far published deal with physics, mathematics, and chemistry.

The present volume covers a somewhat different field. Instead of dealing with a realm of knowledge it deals with a human activity—the Chemical Industry—and while this industry depends in the first place upon chemists and chemical engineers, it requires assistance from devotees of many other disciplines such as physics, mathematics, biology, accountancy, marketing, and such like. Moreover, the sources of information about it are less systematically classified than for the sciences, and other sources of information are often as important as books, e.g. personnel officers, research managers, trade and labour organizations, vacation courses in individual companies, works visits, and so on.

The science of chemistry and the development of the Chemical Industry are inevitably interwoven and a good deal of data relates to the science as well as its application in industry, but we acknowledge in the book on several occasions that for a fuller treatment of chemistry itself the source book in this series is *How to Find Out in Chemistry* by C. R. Burman.

The endeavour is therefore to cover this ground as adequately as possible having in mind that our readers may range from sixth-formers seeking a view of industry, graduates and others considering

a career in it, and trainees within the industry, to business men seeking a little technological information, technologists trying to understand better the activities of their commercial and administrative colleagues, and those others outside the industry curious to know a little of this very interesting sphere of human activity. Specialists within the industry may find the treatment of their own subjects inadequate for them, but the chief purpose of the book is to introduce reading matter and contacts of particular usefulness in the various fields of activity within the industry. The chapters on careers and qualifications and training are addressed essentially to sixth-formers, school-leavers, and young graduates, so that some facts will inevitably appear elementary and self-evident to those well established in the industry.

It is hoped also that this volume will assist in the implementation of the Industrial Training Act, 1964, applied to the Chemical Industry, and that it will thereby encourage technical and managerial innovation. The Minister of Labour has appointed as Chairman of the Chemical Industry Training Board under the Act, Mr. C. M. Wright, formerly Personnel Director of ICI Ltd., and now a member of the Economic Development Committee for the Chemical Industry. This Board will cover about half a million workers in the chemical and allied industries (excluding the rubber and plastics processing industries and leather which have their own boards) and companies will be required to take a close look at the objectives and administration of their training schemes.

Those concerned with the implementation of the Act will require to bring a wider perspective to their deliberations, and this book will economize their time and energy by giving guidance to their reading and useful new contacts. Students entering the industry and trainees already in it will find here much information as to what goes on in different sections of the industry, assisting them to get a balanced picture of the whole.

The authors wish to acknowledge the willing assistance they have had from organizations and societies mentioned in the text for permission to use illustrations and information and in particular the Chemical Industries Association Ltd. They are also

indebted to A. G. Pate and W. A. Price of the Library of the University of Manchester Institute of Science and Technology; B. Rogerson, Librarian of Geigy (UK) Ltd.; D. F. Styles, Information Officer of ICI, Dyestuffs Division; F. R. Taylor, Scientific Librarian of Manchester Central Library; A. M. Volchek of the Moscow Institute for Chemical Machine Design; to Dr. C. M. Cundall and his colleagues in Ferranti Ltd., Wythenshawe, for patient instruction on the computer; to Messrs. Hoare & Co. Investment Research, for permission to quote from their excellent survey of the Chemical Industry; and to Mrs. Patricia Perry for untiring assistance with the typescript.

In such a wide field it is, of course, not possible to include everything, so all sources are selective throughout the book. In case a further edition is warranted we shall be grateful if readers will send names of books and journals which ought to be included, and suggestions for improving the usefulness of the book and for correcting mistakes. Such correspondence may be sent to us care of Pergamon Press, Headington Hill Hall, Oxford.

R.B.

August 1967 G.A.C.

CHAPTER 1

The Chemical Industry

It is well-nigh impossible to give a definition of the Chemical Industry which would satisfy everyone although those engaged in it have quite clear conceptions of what it means to them. There may be slight differences of opinion as to which specialized activities are to be included, such as the ancient crafts of glass-making and paper manufacture, but by and large, wherever chemical reactions take place in a production unit, that is part of the Chemical Industry. A chemical reaction takes place when the raw material with which the process starts is transformed to something having different properties, for example the manufacture of washing soda from common salt or the fermentation of certain grains to alcoholic liquors.

The general public, however, are very vague about the activities and the products of the Chemical Industry. It is true they are familiar with some of its products such as bicarbonate of soda, aspirin, chloroform, sugar, and so on, but they associate these with chemists shops (meaning pharmacists) or grocers, and not at all with the often complicated manufacturing plants where they are made within the Chemical Industry.

Most chemicals never reach the public as they are made to be used in other manufacturing processes—the end products of one factory become the raw materials of another, frequently in the most unexpected way. The by-product, benzene, of the coke ovens can be converted into aniline which in turn may become a raw material for the manufacture of a brightly coloured dye. The coal-tar derivative, naphthalene, may be made into phthalic anhydride which then becomes a raw material for a plasticizer which, when

incorporated into a plastic, can determine how pliable it will be. The Chemical Industry is in fact its own best customer.

Nevertheless, there is scarcely any segment of human activity unaffected by the products of the Chemical Industry.

The food required for an expanding world population could not be grown without the fertilizers, weed-killers, insecticides, fungicides, and soil-treatment chemicals. Amino acids, synthetic vitamins, antibiotics, and antioxidants are all animal-feed supplements assisting meat supplies. For processed foods there are flour improvers, synthetic vitamins, sweetening agents, preservatives, and, of course, the ubiquitous plastic films and other containers for packaging.

The Chemical Industry assists also in the clothing and furnishing industries not only by producing the growing numbers of man-made fibres, but by enhancing the most desirable properties of the natural fibres to make them shrink-resisting, water-repellent, stable in sunlight, moth-proof, and fire-proof.

New plastics have produced wall panels, draperies, table tops, upholstery for our houses and furniture, and some become ingredients of paints to give more durable coatings and to make them easier to apply. The new techniques associated with polymer technology have led to the development of urethane foams for cushions, vinyl flooring tiles, bonded plywood of great strength, plastic insulation materials—in short the building and furnishing of houses have been revolutionized by the Chemical Industry.

In motor-cars and aircraft, chemicals added to fuels and lubricants have improved performance, and completely synthetic lubricants have been synthesized to meet special needs such as wide temperature ranges and high-pressure working. Synthetic rubbers have produced hard-wearing tyres, and natural rubber has been improved by chemical additives. There are also fire-resistant hydraulic fluids. Even journeys into outer space are made possible by the new fuels, lubricants, plastics, etc., produced to rigid specification by the Chemical Industry.

The products used in medicine are perhaps better known

because more universally used, for example the new vaccines and the antibiotics. There are also the hormones, such as cortisone for the treatment of arthritis; butazone for rheumatism; the antihistamines to control certain allergies; the well-known tranquillizers, sometimes abused but a boon to those who use them properly. Yet the potential of the Chemical Industry for still greater advances in the future of medicine is enormous.

These examples could be multiplied many times, but they serve to illustrate the scope of this many-sided complex industry to which the present volume is an introduction and guide.

An amusing, non-technical but essentially realistic introduction to recent developments in the industry to 1945 is W. Haynes, *This Chemical Age* (Secker & Warburg, London, 1945).

The background science on which the Chemical Industry is based is, of course, chemistry. We are not here covering the various sections of the science itself as this has already been done in the companion volume, C. R. Burman, *How to Find Out in Chemistry* (Pergamon, Oxford, 1965). It is another indication of the complexity of the industry, however, that it employs not only chemists and chemical engineers, but also physicists, mathematicians, and biologists to control its technical department besides also all the essential administrative and commercial specialists.

The Early Days

Although we would say that the beginnings of the Chemical Industry date from the Industrial Revolution at the end of the eighteenth century, and that it began to take on its present structure in the various mergers of the 1920's resulting, among other things, in the formation of Imperial Chemical Industries Ltd., it is true also that some products date back to prehistoric times, and many became known in the intervening period. They originated in fact in the ancient crafts, painfully and slowly evolving by the sheer trial and error of empiricism without thought of the underlying science and technology.

The smelting of metals was probably the first chemical process

discovered by man. Gold, copper, iron, lead, silver, and quicksilver were all used in Ancient Egypt, for example, and the alloy bronze (copper–tin) was used before iron. Leather-working is an ancient craft, and the use of alum in preparing the hides was known from the earliest times. Dyeing was carried out using local herbs and lichens, but outstanding dyes were the famous indigo, a plant extract, and Tyrian purple, the royal purple of Rome, an extract from a small Mediterranean mollusc. Also known were glazed pottery and glassware; soda, caustic soda, and potash were all used in glass making; soap and some cosmetics were well known, and among the various materials usually classed as chemicals, the ancient Egyptians knew saltpetre, sal ammoniac, common salt, sulphur; they had sugar, oils, fats, waxes; and they made alcohol by fermentation and knew they could take the process a stage further to get acetic acid (vinegar). For many years—practically 2000—progress was made only in the craftsmanship, but not at all in the chemical theory. One of the obstacles lay in the social attitude to experiment: it was regarded as an occupation for slaves. Free men were free to observe and to think about what they saw, but experimentation was something menial. The Greeks and Romans therefore did not add much to the progress of practical science. The Arabs, on the other hand, were great experimenters and added new knowledge and understanding, especially about the mineral acids.

Then followed a period of practically five centuries in which the thoughts of the experimenters—the alchemists—were turned to the supreme task of the transmutation of the base metals into gold. It was a time of great activity and experiment; many new reactions were studied, and new materials and new laboratory apparatus were produced. Unfortunately there was much trickery and false reporting. Even valuable information was hidden in mysticism and allegorical language. The facts were known to those involved in the practice but no theory was worked out.

In the seventeenth century, following the advice of Francis Bacon to collect the facts and then work out theories based on these facts, Robert Boyle and Isaac Newton and their friends of

the then newly founded Royal Society led the way into a systematic study of the underlying theory, a work notably carried on in the following century by Lavoisier (who explained the nature of combustion) and Priestly and Black.

In 1808 John Dalton published an account of his atomic theory and thus the stage was set for a great forward movement in the understanding of chemical reactions which enabled the pioneers in chemical manufacture to use the new sources of power which then became available to them.

For more detail of this background see T. I. Williams, *The Chemical Industry* (Penguin, London, 1953). Besides describing the beginnings, this book traces the subsequent development and discusses the present organization.

An interesting book tracing the history of one chemical—alum—mentioned above and typical of others which may be consulted, was produced by Peter Spence & Sons Ltd. to mark their centenary: C. Singer, *The Earliest Chemical Industry* (1948).

The Industrial Revolution

With the coming of the Industrial Revolution at the end of the eighteenth century it became possible to make many materials in large quantities, and with the establishment particularly of textile mills there grew a corresponding demand for larger quantities of soap, alkalis, and acids. Certain chemicals became fundamental needs in a number of industries, notably mineral acids (sulphuric, nitric, and hydrochloric) and alkalis (soda and caustic soda) and about this time improved processes were worked out.

Alkali

Alkali used to be obtained by burning certain vegetable plants which yielded alkaline ashes. With growing demand the supply soon became inadequate, and a good deal of investigation was proceeding to find a better supply. In 1775 the French Government offered a large cash prize for such a process, and Leblanc

worked out a method starting with common salt as raw material, treating this with sulphuric acid to get sodium sulphate which was then mixed with limestone and coal to give a mixture called "black ash". This was subsequently extracted with water to dissolve out the soda which was finally crystallized. The process was effective but somewhat wasteful, especially of the valuable sulphur component, and it ran into trouble also because of the copious noxious fumes of hydrochloric acid which, in the beginning, had to be allowed to escape into the atmosphere. Nevertheless, it marked the establishment of the famous Alkali Industry and continued for nearly a century before being displaced by the Solvay ammonia–soda process.

The ammonia–soda process began by treating common salt with ammonia and carbon dioxide, leading to the formation of ammonium chloride and sodium bicarbonate. The latter was then heated to give sodium carbonate (soda) by giving off carbon dioxide which was then used over again to treat more salt. The ammonium chloride can also be heated with lime to give calcium chloride and ammonia which can also be used over again. This is, therefore, a very economical process and gradually ousted its competitors. The soda comes on the market in two forms—soda ash (a dry white powder) and also a hydrated crystal form, well known as washing soda.

A stronger alkali (caustic soda) is frequently required in certain industries and was made by treating soda ash with lime, but today it is made direct by the electrolysis of salt solution, yielding another important basic chemical—chlorine—as a by-product.

Sulphuric Acid

Meanwhile the manufacture of sulphuric acid in ever-increasing quantities was growing apace. The first important large-scale manufacture was known as the "lead chamber" process, still important today with modifications. It is based on the observation that lead is resistant to sulphuric acid. In the lead chambers a

mixture of sulphur and nitre (potassium nitrate, also called saltpetre) was burned in a stand over a layer of water, the products of combustion being gradually dissolved in the water. After a series of burnings the dilute sulphuric acid was removed and concentrated by heating in other lead vessels. Many improvements and modifications have been made in the process, but it is still used to a certain extent especially in the United Kingdom. The supply of sulphur is not now so plentiful so that other raw materials are used, particularly pyrites (a crude iron sulphide), and improvements have been made in the burning equipment.

Another process for sulphuric acid is known as the "contact process". This did not develop very quickly at first because it did not show any obvious advantages over the lead-chamber process. With the later development of organic chemicals and the need in many reactions for a more concentrated form of sulphuric acid (oleum) than could be made in the lead chambers, the development of the contact process then moved ahead rapidly. The essential stages of the contact reaction are (1) the burning of sulphur to sulphur dioxide, and (2) the conversion of sulphur dioxide to sulphur trioxide (anhydrous sulphuric acid) by mixing with air and passing over heated finely divided platinum as a catalyst. The sulphuric acid thus formed is already in the form of oleum, so that no costly evaporation is necessary.

Both these processes are carried out on a very large scale today. It used to be said that the standard of industrialization of modern nations could be assessed by comparing the use of sulphuric acid per head of population. Nowadays a better measuring stick is probably steel or plastics. It is still, however, a useful indication of the state of activity in the UK Chemical Industry as it is required in so many processes, and the UK production is almost entirely used for home consumption.

Similar interesting stories can be told relating to the other fundamental chemicals developed in large quantities during the course of the Industrial Revolution—ammonia, chlorine, hydrochloric acid, nitric acid, alum and soap.

Organic Chemicals

The textile dyers were among the largest users of the products of the growing Chemical Industry throughout the nineteenth century. At the beginning all dyes were of vegetable or animal origin, most of them handed down from ancient times, such as indigo, madder red, Tyrian purple, certain lichens, cochineal, cutch, litmus, logwood, safflower, and turmeric. It was not until 1856, when William Henry Perkin discovered his first synthetic organic dye, mauveine, that the dyestuffs industry began to develop the large range of synthetic dyes derived mainly from coal-tar. This was an extremely important event in the Chemical Industry as it influenced not only dyes and dyeing but initiated a new mental approach to synthetic chemistry and started great new industries—pigments, pharmaceuticals, plastics, explosives, fertilizers, and others.

Growth of the Industry

In spite of the prominent part played by British chemists and technologists in these early years of development, the latter half of the nineteenth century and the years before World War I were years of wasted opportunity for Britain. It is true that Ivan Levinstein had founded a dyestuff factory in Manchester in 1864 and this was the biggest dye factory in the country on the outbreak of war in 1914. It was soon evident, however, that Britain had allowed herself to become too dependent on the German Chemical Industry. Over 80 per cent of the dye requirements of the United Kingdom were imported. The British patent law permitted other nationals to take out patents in Britain without working them here. Foreign dyes were allowed to come into the country without duty. There was also a heavy tax on industrial alcohol. There was a shortage of intermediates, and even of oleum.

Much leeway had to be made up during the war and in the postwar years. After World War I the Chemical Industry and what it could do began to be fully recognized by the Government, and steps were taken on many sides to assist in strengthening it. The

Dye-stuffs (Import Regulations) Act, 1920, was the first legislative step taken, and by 1930 the import of dyes had fallen to 20 per cent of the total requirements and is now less than 5 per cent, although the Act has since been repealed.

The Safeguarding of Industries Act, 1921, imposed key industry duty of 33⅓ per cent on the importation of fine chemicals. This helped Britain to create an elaborate synthetic organic chemical industry, and to set up the necessary research and development to become one of the leaders.

During the war the deficiencies of the British Chemical Industry had been exposed, and energetic steps were taken to increase production of oleum, the necessary high explosives, dyes, fertilizers, and many other chemicals, both organic and inorganic. Germany had scored a great chemical triumph in perfecting the so-called Haber–Bosch process for using the nitrogen of the air in combination with hydrogen from water to make ammonia and nitric acid, and ultimately the necessary nitrogenous fertilizers to make her free from imports of such materials. This process was not established in Britain until some years after the war—about 1922.

The momentum which chemical activities acquired at that time continued long after that war and continues today. The effort put into research and development has produced new products of outstanding properties in almost every field of the Chemical Industry, and the new applications of plastics have led to a great new industry unknown before 1920. There was also much rearrangement to be done to scale down the manufacture of war materials and to transfer plant to new products and processes required for a world at peace.

In the midst of all this it was soon appreciated that for the economic production of chemicals the unit of production had to be much greater than had been customary, and mergers began to take place of the numerous small chemical manufacturers to form larger organizations able to deal with the quantities required to take an appreciable share of world markets.

Such a merger resulted in the formation of Imperial Chemical Industries Ltd., now one of the giants of the world Chemical Industry.

It was formed in 1926 by a merger of Nobel Industries Ltd. (itself the result of previous mergers); Brunner, Mond & Co., the leading heavy chemical manufacturer (which had previously taken over Chance & Hunt Ltd. and Castner–Kellner Alkali Co. Ltd.); United Alkali Co. Ltd.; and British Dyestuffs Corporation Ltd. (the merger of British Dyestuffs Ltd., Levinstein Ltd., and later Scottish Dyes Ltd.).

The story of this merger is an interesting one and is graphically told in *I.C.i.: a Survey by The Times* (London, 1962).

Germany already had its great dye trust, IG Farbenindustrie (1925), making not only dyes but heavy and fine chemicals of all kinds. America had the Dupont Company and Allied Chemical & Dye Corporation formed in 1920. In France and Italy there were similar organizations. In spite of the instinctive dislike by governments of trusts and monopolies it was recognized throughout the world that large production units were necessary in the Chemical Industry to compete in world markets.

The Present Structure

Following World War II, of course, the processes of amalgamation and merger continued resulting in the development of such giants of the industry as Courtaulds, Distillers, British Oxygen; the oil companies Shell, Esso, and BP; Fisons, Unilever, Albright & Wilson, Laporte; Goodlass Wall and Lead Industries; Berger, Jenson & Nicholsons; Beechams, Glaxo; Newton Chambers, Imperial Smelting Corporation—all employing capital of £10m to over £100m, and there are many more only slightly smaller and still growing.

The larger units in which these companies deal have led to such a rate of progress as could not have been visualized in previous decades.

Fortunately a book has recently been published which for the first time gives a detailed survey of the development of the British Chemical Industry as it is today—D. W. F. Hardie and J. Davidson Pratt, *A History of the Modern British Chemical Industry*

(Pergamon, Oxford, 1966). This gives an excellent description of how the various chief chemicals have been produced and how the chief companies have been formed. It includes a list of trade associations and a most carefully prepared chart showing the principal products of the industry, giving a clearer picture of their relationships than could ever be given by words alone.

The following is a very brief summary of the main stream of development outlined in Hardie and Davidson Pratt to bring this survey up to date.

Chlorine and caustic soda are almost wholly made by the electrolysis of brine, and liquid chlorine has replaced the earlier bleaching powder. ICI is now the sole supplier of soda ash.

Sulphuric acid is made chiefly by the contact process and, in addition to brimstone, many new sources of sulphur are ultilized as raw material, such as iron pyrites, spent oxide, anhydrite, and sulphuretted hydrogen from petroleum refineries. The biggest uses of the acid are for the fertilizer industry (superphosphate), for pigments and rare earths, for sulphate of ammonia, and in rayon manufacture.

Hydrochloric acid is now made chiefly by combustion of chlorine gas in hydrogen, both being products of the electrolysis of brine. Nitric acid is chiefly made by the modern (Ostwald) process, the catalysed oxidation of ammonia.

The Haber process for ammonia is now worked in the United Kingdom by ICI, Fisons, and Shell, and represents one of the most highly automated processes in the industry. This process also yields the cyanides for gold mining and other metal industries, and for plastic manufacture (e.g. Perspex).

Acetylene is still produced largely from calcium carbide as raw material, but the closer co-operation between the petroleum and chemical industries opens up new ways of producing acetylene which are already being investigated, one being worked by ICI.

The story of phosphorus chemicals in the United Kingdom is largely the story of Albright & Wilson, while the peroxide chemicals are made chiefly by ICI, Laporte, and Alcock (Peroxides) Ltd.

The supply of industrial gases is dominated by British Oxygen. Silicon Chemicals have a growing importance being developed by ICI and Unilever (Crosfields), as have also fluorine compounds being developed by ICI and Imperial Smelting Corporation.

Chromium compounds, white lead, titanium oxide, bromine, alum, and aluminium salts, and many other heavy inorganic chemicals are produced in increased quantities and high quality.

These examples serve to show the growing scope of the industry today, even in its basic products, and the following specialized sections illustrate how each part has gradually acquired an importance as an industry group in its own right.

Dyes and Organic Pigments

The dyestuff section is now strong enough to stand on its own feet without the protection of the Dyestuffs Act, and can indeed boast of real world-contributions in research and development.

The main advances of the past few decades have been in the direction of increased fastness to light both in dyes and pigments, continuing the tradition established in 1921 with the introduction of Caledon jade green by Scottish Dyes, subsequently followed by the Soledon dyes, a solubilized range. In 1934 the first really stable pigment blue was introduced by ICI—phthalocyanine blue, and is now made by several manufacturers. Later this also was introduced in a soluble form (alcian blue) which made it suitable for dyeing certain fibres.

Efforts have long been made to produce dyes with a real chemical affinity for cellulose, and in the early 1950's the Procion range of ICI (the so-called reactive dyes) solved the problem. These also are now made by many other dye manufacturers.

Meantime the growth and spread of newer man-made fibres posed serious problems for the dye chemist, each fibre having its own peculiar properties. In some cases new dyes were formulated, in others new processes of application.

Now the number of dyes and pigments in use in industry is well over three thousand, a tribute to the research efforts which were

necessary to meet a long list of specifications and an ever widening range of new fibres and mixed fabrics introduced by the textile industries.

Pharmaceuticals

The last 30 years have seen tremendous strides in this section, indeed it has been said that over 70 per cent of the prescriptions used by doctors today could not have been written in 1935, the year of the first sulphonamide drug. The story of the sulphonamides has become common knowledge, but equally fascinating stories could be told about the antimalarials and the drugs for the treatment of coronary disease, hypertension, leukaemia, leprosy, sleeping sickness, and tuberculosis.

The production of penicillin and other antibiotics has now assumed large proportions, and the development of the manufacture of penicillin and its various modifications and derivatives from the "small bottle" processes to really large quantities is one of the highlights of the industry.

The recognition of the importance of the hormones soon led to high production—adrenaline, insulin, thyroxine, cortisone, and the sex hormones—each one important in the treatment of disease. The new anaesthetics "trilene" and "fluothane" are already well established.

Vitamins also represent a recent development of great importance to humanity. Eight had been recognized by 1935, and although they are quite dissimilar chemical compounds, they have been synthesized and are made on a large scale. The UK annual output of vitamin C, for example, is of the order of 4000 tons!

Pest Control

Before the 1930's, apart from the use of lime sulphur against plant mildew, mercuric chloride as a seed dressing, copper fungicidal dusts, and tar-oil sprays, the chief pesticidal products used in agriculture, horticulture, and in public health were the natural

extracts of derris and pyrethrum. During World War II the supply of these insecticides became difficult, and when the Swiss firm of Geigy demonstrated the insecticidal action of DDT in 1939, it was immediately in great demand and the efforts of the warring nations were committed to ensure adequate supplies. There followed great activity in research work in this field, resulting in many new specialized insecticides, but DDT is still the most widely used insecticide both in public health and crop protection.

Weed-killers represent large tonnage production today, some being "selective", destroying certain weeds growing among specified crops, and others "total", being used for clearing paths, roadsides, docks, yards, and so on.

Plastics

These are mostly quite new materials, not strictly speaking "chemicals" in themselves because they are characterized by their exceptional stability rather than by chemical activity, although they are, of course, produced by chemical processes. They replace in their applications some of the traditional materials such as wood, leather, metals, concrete, glass, and ceramics.

Rubber, cellulose acetate, casein, and celluloid occupied a transitional period between the traditional materials and the new plastics, the first truly synthetic plastics being the phenolformaldehyde plastics (PF) and the urea-formaldehyde plastics (UF).

As the background science of the high polymer technology gradually evolved through the studies of men like Staudinger in Germany and Carothers in America, it became evident that there were many possibilities of condensation between new starting ingredients, and a whole range of polymers gradually came into production.

During World War II, for example, four new plastics were produced in very large tonnages—polyethylene, nylon, PVC (polyvinyl chloride) and polystyrene, and shortly after the war there were established in the United Kingdom the synthetic rubbers, silicones, polyurethanes, and epoxy resins.

The realization that petroleum could become an important source of raw materials previously obtained only from coal tar, and the closer understanding between the petroleum refining and the chemical industries opened the way to greatly increased supplies of raw materials for the growing plastics industry.

Production has therefore increased year by year to become a large tonnage output in the United Kingdom today.

The following list includes the chief polymers produced together with the names of the firms involved in the developments in the United Kingdom:

PF (phenol-formaldehyde)	Bakelite
UF (urea-formaldehyde)	British Industrial Plastics
Methyl methacrylate (perspex)	ICI
Polystyrene	Monsanto, British Resin Products, BX Plastics, Shell
Polyethylene	ICI
Nylon	ICI, British Enkalon, Chemstrand
PVC	ICI, Distillers
PTFE	ICI
Silicones	Albright & Wilson, ICI
Polyurethanes	ICI
Epoxy resins	Shell
Terylene	ICI
Synthetic Rubbers	ICI, Esso, Dunlop, Dupont
Polyacrylonitrile	ICI, Chemstrand
Polypropylene	ICI

General

In addition to these specialized spheres within the Chemical Industry there is a wide range of "heavy" organic chemicals manufactured in large tonnages to serve as raw materials and intermediates. Such are the chlorinated hydrocarbons (solvents), alcohol, the coal-tar chemicals, petrochemicals, the non-soap detergents ("whiter than white!"), and the range of plasticizers.

The foregoing summary will convey to readers the wide variety of products and the large number of processes involved in the Chemical Industry.

Its turnover is the second highest in the manufacturing industries of the United Kingdom (mechanical engineering being the highest); output in 1965 was estimated to be £2500m; it accounts for about 9·5 per cent of manufacturing output, over 12 per cent of capital stock, but requires only about 6 per cent of the total labour employed in the manufacturing industry. In 1964 it was calculated that the capital employed per man was £5780 compared with £2462 for the manufacturing industry generally, which is a high proportion of capital in relation to labour as it is an industry of rapid obsolescence of plant or process as research provides new products in quick succession. Output per man was valued at £5812 in 1965, compared with £3200 for the manufacturing industry generally. In 1965 chemicals accounted for 11·5 per cent of the manufactured exports, valued at £440m, and for 13·7 per cent of the manufactured imports, valued at £283m, showing a favourable net balance of exports of £157m, as a contribution to Britain's export effort. The North Sea gas discoveries could be very important for the Chemical Industry, providing a cheap source of energy as well as being used to replace naphtha as a basic feedstock in manufacture.

It can be seen therefore that the Chemical Industry is a "growth" industry and presents particular opportunities of progress and development at all levels of employment.

The buoyancy of the UK chemical market is also illustrated by the number of manufacturing units set up in this country by overseas companies, and these also, of course, present opportunities of employment. Examples are American Cyanamid, Allied Chemical, Dupont, Union Carbide, Hercules, Monsanto, Dow, Pfizer, and Proctor Gamble from the United States; Ciba, Geigy, Sandoz, and Roche from Switzerland; Organon from Holland; BASF, Hoechst, and Bayer from Germany, and very many others.

Classification of Chemical Products

We have already stated (p. 1) that wherever chemical reaction takes place in a production unit, that is part of the Chemical Industry, but as a definition this is too wide for practical purposes. Two official attempts have been made at definition.

The first is that adopted in the Standard Industrial Classification maintained at the Central Statistical Office, Great George St., London, and used by government departments for compiling official statistics. The section dealing with the Chemical Industry is "Order IV, Chemicals and Allied Industries", thus avoiding the need for an exact definition. This includes coke ovens and mineral-oil refining, and would probably be modified if it were being considered today, but it provides a useful measuring stick for a clearly described section of industry (Table 1).

TABLE 1. STANDARD INDUSTRIAL CLASSIFICATION: ORDER IV, CHEMICALS AND ALLIED INDUSTRIES

261	Coke Ovens and Manufactured Fuel
262	Mineral Oil Refining
263	Lubricating Oils and Greases
271	Chemicals and Dyes
272	Pharmaceutical and Toilet Preparations
273	Explosives and Fireworks
274	Paint and Printing Ink
275	Vegetable and Animal Oils, Fats, Soap and Detergents
276	Synthetic Resins and Plastics Materials
277	Polishes, Gelatine, Adhesives, etc.

The second attempt at definition was that drawn up by the Association of British Chemical Manufacturers in 1949 when asked by the Board of Trade to prepare a survey of the industry past, present, and future. This covered heavy chemicals, industrial gases, fertilizers, dyestuffs, medicinal and other fine chemicals, explosives, plastics, and synthetic resins, but not the compounding of chemicals to make such products as paints, insecticides, sheep

and cattle dips, and pharmaceutical preparations. Synthetic fibres and rayons were not included, but the chemical raw materials used in their manufacture were included in the survey.

In practice, however, many chemical manufacturers also make the specialized products, and many who started by making only the specialized products safeguarded their own raw materials by going into true chemical manufacture. These specialized industries have therefore come to be regarded as belonging to the group of chemical industries and in their handbook for 1963 the Association of British Chemical Manufacturers issued a new classification headed "Grouping of Chemical Industries" (Table 2).

TABLE 2. THE ASSOCIATION OF BRITISH CHEMICAL MANUFACTURERS GROUPING OF CHEMICAL INDUSTRIES GROUP CLASSIFICATION CODE

Inorganic Chemicals

I1 Acids
I2 Alkalis
I3 Rare earths and compounds
I4 Precious and rare metals and compounds
I5 Gases
I6 Others (a) Metallic
(b) Non-metallic

Organic Chemicals

O1 Aliphatic heavy chemicals
O2 Aromatic heavy chemicals
} after O1, and/or O2 the letters (ct) or (p) have been added where members wish to indicate that their production is based on coal-tar or petroleum respectively

O3 Fine organic chemicals
O4 Oils, fats, and waxes
O5 Other organic chemicals

Specialised Products

S1 Adhesives and gelatines
S2 Detergents and other surface active agents
S3 Disinfectants
S4 Dyestuffs
S5 Essential oils, isolates, perfumes, and synthetic aromatics
S6 Explosives
S7 Fertilisers
S8 Fire-fighting agents

S9 Fire-proofing agents
S10 Foodstuffs additives
S11 Foundry preparations
S12 Fuel and oil additives
S13 Greases and lubricants
S14 Laboratory chemicals and reagents
S15 Metal treatment and anticorrosive products
S16 Paints and surface coatings
S17 Pest control products (a) Fungicides
(b) Herbicides
(c) Insecticides
(d) Others
S18 Pharmaceutical preparations
S19 Photographic chemicals
S20 Pigments (a) Coloured
(b) White
S21 Plastics
S22 Plasticizers
S23 Refrigerants and aerosol propellents
S24 Rubber chemicals
S25 Silicones
S26 Soaps
S27 Solvents
S28 Resins
S29 Synthetic rubber
S30 Tanning and leather materials
S31 Textile and dyeing auxiliaries
S32 Veterinary preparations
S33 Water treatment chemicals

(By permission of the Chemical Industries Association Ltd.)

It would, of course, be desirable for government departments and industry to accept the same classification and no doubt one day this will be achieved, but any alteration in the official list would, of course, nullify for a time the possibility of comparative statistics, unless the old and the new series were run together for an agreed period of years.

In the United States there are two corresponding classifications:

1. *The Standard Industrial Classification* Section 28—Chemicals and Allied Products, issued by the US Census of Manufacturers.

2. *The Chemical Process Industries*, issued by McGraw-Hill as "Census of Plants and Employees, Chemical Process Industries, 1959", published in *Chemical Engineering*, a McGraw-Hill publication.

Statistics in the Chemical Industry

It is a common complaint of the industry in the United Kingdom that the statistics available are painfully inadequate, but it is generally conceded that much of the blame for this lies with the industry itself due to the reluctance with which companies provide the necessary information. While it is understandable that hard-won knowledge tends to be carefully guarded, and that the successful exploitation of a special market is not to be "shouted from the housetops" so that competitors can take advantage of it, nevertheless the provision of information on such things as production, sales, exports, capital investment, labour, new products, prices, and so on is an essential prerequisite for the provision of useful statistics. These can be collected by the Government or by industry itself through trade associations. They are even more useful when broken down into regions, industries, and in some cases into individual products.

There is a growing awareness in the Chemical Industry of this need, particularly in the field of marketing research, and discussions are already taking place on the basis of a report submitted by the Chemical Industries Association, which will no doubt lead to improved statistics one day.

In the meantime there is still available an appreciable amount of information on the Chemical Industry, although it is very much better in the United States than in the United Kingdom.

United States

Chemical Statistics Directory, No. 3, issued by the US Dept. of Commerce, is a complete guide to US Government statistics relating to the Chemical Industries. It lists in alphabetical order

the Chemicals of Group 28 (Chemicals and Allied Products) of the US Standard Industrial Classification and the raw materials for these chemicals. Then, in four columns, it gives (1) the source of statistical information, (2) type of data recorded, (3) page, and (4) volume. There is also an addendum of detailed information about the fifty-odd sources which have been studied in compiling the directory.

This can be amplified by reference to three other valuable guides:

Statistics Sources, 2nd edn., Gale Research Co., Book Tower, Detroit 26, Mich., 1965.

Chemical Market Abstracts (monthly), Foster D. Snell Inc., 29 West 15th St., New York. This includes much statistical information in addition to that on products and scientific matter.

Sources of Commodity Prices, Special Libraries Association, 31 East 10th St., New York 5, 1959. This shows that the overwhelmingly chief source of prices for chemicals is the *Oil Paint and Drug Reporter*.

United Kingdom

Unfortunately there is no corresponding directory of chemical statistics in the United Kingdom, and the *List of Principal Statistical Series Available* (1965), issued by the Central Statistical Office (Great George St., London, SW 1), is quite general and the chemical information has to be extracted tediously item by item from the various sources named. Nevertheless, this *List* is the convenient reference from which to begin statistical research.

In addition there are three very useful government publications which collect and collate statistics as they appear in original source publications:

1. *Board of Trade Journal* (weekly)

This is, of course, a mine of information on all sorts of official and business activities, and each copy contains at the end an index

of all the statistics published regularly in the *Journal*. Many of these are very general and have no bearing on the Chemical Industry, but the following are of interest.

(a) Balance of Payments (quarterly)—there is no breakdown.
(b) Capital Expenditure by Industry (quarterly)—broken down generally as far as "Manufacturing industry", but shows "Chemicals, paint and printing inks" as one total for fixed-capital expenditure.
(c) Industry's Investment Intentions (3 times per year)—very widest terms with no analysis.
(d) Chemical Industries Production (6-monthly)—the most detailed analysis available.
(e) Companies—Incomes and Finance (quarterly)—mostly refers to "Manufacturing industries", but in some cases to "Chemicals and allied industries".
(f) International Trade Credit (annually).
(g) ECGD Business (quarterly)—refers to Export Credits Guarantee Department.
(h) Foreign Trade—Commonwealth (annually).
EFTA (quarterly).
Sterling Area Trade Summary (quarterly).
Trend to Exports of Manufacturers (annually).
World Trade and Production (quarterly).
These are mostly in general terms but the Sterling Area Summary is broken down to "Chemical industries" and certain subsections.
(i) Foreign Trade of the United Kingdom:
Unit value and volume index nos. (monthly).
Value of overseas trade (monthly).
Overseas trade, analysis of trends (quarterly).
One subsection is "Chemicals".
(j) Industrial Building Provisional Figures (quarterly)—general totals only, but broken down into regions.
(k) Industrial Production, index nos. (monthly).

(l) Investment and Earnings Overseas (annually)—broken down only to "Manufacturing industries".

(m) Stocks, Manufacturers, Wholesalers and Distributors (quarterly)—show "Chemicals and allied industries" as separate analysis.

(n) Wholesale Prices—average prices of selected commodities (annually)—index nos. (monthly). Broken down to "Chemicals and allied industries".

2. *Monthly Digest of Statistics*

This collects statistics as they appear and also publishes comment upon them. Such items are considered as National Income and Expenditure, Labour, Industrial Production, in which Chemicals are broken down into subsections such as fertilizers; sulphur and sulphuric acid; synthetic dyes; colours; paints; varnish; synthetic resins and plastics; miscellaneous.

3. *Economic Trends* (monthly)

This is published for those who wish to follow the main trends of the economic situation in the United Kingdom and it brings together the main statistical series covering employment, output, consumption, prices, trade, and finance. Usually the figures are not analysed further than "Manufacturing industries", but occasionally this is divided further to "Chemicals and allied industries", as, for example, in the index of industrial products, where there is illustrated a graph showing productions from 1957 to date. There is also a useful index of sources of statistical data.

Study of the above publications will guide the reader to all official sources of statistical information on manufacturing industry and frequently on chemicals and allied industries, but for some detailed information the following are also of particular importance.

Census of Production

The last publication related to the year 1958, but the data for 1963 are being published this year.

Information includes working proprietors; employment; wages and salaries; materials and fuel purchased; work given out; transport payments; stocks; capital expenditure; sales and work done.

The industries are listed according to the British standard industrial classification in which section 4 is "Chemicals and allied industries". In the 1958 census this was broken down into subsections, each having a booklet to itself as under:

Subsection	261	Coke Ovens and Manufacturing Fuel
	262	Mineral Oil Refining
	263	Lubricating Oils and Greases
	271/1	Dyestuffs
	271/2	Fertilizers and Chemicals for Pest Control
	271/3 (part)	Coal Tar Products
	271/3 (part)	Chemicals (general)
	272/1	Pharmaceutical Preparations
	272/2	Toilet Preparations
	273	Explosives and Fireworks
	274	Paints and Printing Inks
	275/1	Vegetable and Animal Oils and Fats
	275/2	Soap, Detergents, Candles, Glycerine
	276	Synthetic Resins and Plastics Materials
	277/1	Polishes
	277/2	Gelatine, Adhesives, etc.

Board of Trade Business Monitor Series

This is a series of leaflets on production in certain specialized industries and the following titles are current.

P.11 *Toilet preparations* (quarterly)
P.18 *Paint and Varnish* (quarterly)
P.19 *Colour* (quarterly)

P.20 *Synthetic Detergents and Soap* (quarterly)
P.21 *Plastics Materials and Synthetic Resins* (quarterly)
P.22 *Polishes* (quarterly)
P.41 *Leathercloth* (quarterly)
P.57 *Salt* (monthly)
P.58 *Pesticides and Insecticides* (quarterly)
P.66 *Organic Chemicals* (quarterly)

Overseas Trade Accounts of the United Kingdom

This is published monthly with cumulative totals and contains imports, exports, and re-exports. It gives totals and sectional totals (section 5 is Chemicals, this being the number in the standard international trade classification). There is also a good index of individual products.

Annual Abstract of Statistics

This is, of course, very much wider than any individual industry, but it contains the following items of interest:

Exports, imports
Inorganic chemicals, production
Organic chemicals, production
Earnings
Employed
Census of production
Trading profits (by industry)
Index of prices of selected materials
Size of establishments
Unemployment

Employment and Productivity Gazette (monthly)

Authentic statistics relating to employment, unemployment, unfilled vacancies, overtime, short time, wage rates, retail prices, and stoppages.

The following three special productions will be of particular interest:

Manpower in the Chemical Industry, 1967

The Economic Development Committee for the Chemical Industry (EDCCI)

The Chemical Industry 1965/66 (OECD)

Classified according to the agreed Standard International Trade Classification in which section 5 is "Chemicals", subdivided further into divisions as under:

Division	51	Chemical Elements and Compounds
	52	Mineral Tar and Crude Chemicals from Coal, Petroleum, and Gas
	53	Dyeing, Tanning, and Colour Materials
	54	Medicinal and Pharmaceutical Products
	55	Essential Oils and Perfume Materials: Toilet, Polishing and Cleaning Preparations
	56	Fertilizers, Manufactured
	57	Explosives and Pyrotechnic Products
	58	Plastic Materials, Regenerated Cellulose, and Artificial Resins
	59	Chemical Materials and Products
	599.2	Insecticides, Fungicides, Disinfectants (including sheep and cattle dressing) and similar preparations
	599.5	Starches, Insulin, Gluten, Albumin-Oils, Glues
	599.6	Wood and Resin-based Chemical Products
	599.7	Organic Chemical Products not elsewhere specified
	599.9	Chemical Products and Preparations not elsewhere specified.
From section 2		Crude Materials, Inedible (except fuels).

Division 231.2	Synthetic Rubber and Rubber Substitutes.
From section 8	Miscellaneous Manufactured Articles
Division 862	Photographic and Cinematographic Supplies.
862.3	Chemical Products and Flashlight Material of a kind used in Photography.

Analytical Tables of EEC Foreign Trade

These are issued by the Statistical Office of the European Communities, 170 rue de Loi, Brussels, in 12 volumes, labelled A–L. Volume C (Chapters 28–38) deals with individual chemical products for 1966 and has just been published. These products are classified according to the Harmonized Nomenclature for Foreign Trade Statistics of the EEC member countries (NIMEXE), which replaces the previously used Statistical and Tariff Classification for International Trade (CST). Complete records are given of exports and imports to and from the EEC countries to all other countries and to each other. A copy of the NIMEXE classification is necessary for interpreting the figures given, but there is also an appendix giving the CST numbers for each NIMEXE reference.

Readers may also be interested to know the complete list of Tables—(A) Agricultural Products, (B) Mineral Products, (C) Chemical Products, (D) Artificial Materials, Leather, (E) Wood, Cork, Paper, (F) Textiles, Footwear, (G) Stone, Plaster, Ceramics, Glass, (H) Iron and Steel, (I) Other Base Metals, (J) Machinery, Appliances, (K) Transport Equipment, (L) Optical, Precision Instruments.

Non-government Sources

The Chemical Industries Association naturally keeps its members supplied with statistical information as it appears from time to time, and carries out its own surveys on the state of opinion in the industry. Some of this information is also included in the annual report.

The international chemical trade journal, *Chemical Age*, publishes each September its own survey of UK plant projects, a most useful contribution to the statistical information of the industry. The survey includes all capital projects completed in the past 12 months or which are still in hand, and the last survey, in September 1967, listed 466 projects valued at £930·2m. The name of the main contractor is also included where known.

CHAPTER 2

Careers in the Chemical Industry

THE Chemical Industry, being a growth industry of great complexity as shown in the previous chapter, both as to the ever-increasing demand for established products and the new products regularly produced by research, presents excellent opportunities of progress for all recruits of ability. Moreover, the rate of change is so apparent that adaptability and the willingness to accept new ideas and new procedures are among the personal qualities essential for those anxious to achieve success. Indeed, this flexibility of thinking is what makes the Chemical Industry an interesting and adventurous career, not only for the chemist, physicist, engineer, biologist, and other scientists, but also in the administrative and commercial fields.

The aspiring candidate may seek a position in one of the very large organizations or in a small firm or in one of the research associations set up with government assistance to serve an individual section of the industry. Each of these has its own advantages and drawbacks. The large organizations assure well-equipped laboratories and offices and a full complement of specialists so that one can feel a member of a very efficient team able to study a problem intensively. Great satisfaction can come from the thoroughness of this approach. With the smaller firm one is called upon to carry out a greater variety of functions and to regard problems in a wider framework. This too can be very exhilarating, and one feels more individualistic in a shorter time. Progress in the larger company may be slower unless outstanding work is done, but security may be greater. These points appeal variously to different personalities but it is well to weigh them up before making applications, or at any rate before finally deciding.

The research associations are listed elsewhere (see Chapter 8) and may prove attractive to certain scientists as they are free from the day-to-day diversions of industry itself so that longer-term work can go on without interruption. This is, of course, also the case in research laboratories of the larger companies.

The Association of British Chemical Manufacturers published a brochure, *The Chemical Industry—A Career for You*, which is still available. Since then this organization has amalgamated with the Association of Chemical and Allied Employers to form the recently created (1966) Chemical Industries Association Ltd. (Alembic House, 93 Albert Embankment, London, SE 1), and no doubt this publication will be kept up to date. In the meantime the above-mentioned volume is most useful, as in the appendix there is a list of chemical companies in the United Kingdom with details of the type of work they offer and training courses provided.

More detailed guidance relating to the specialized chemical industries as listed on p. 18 can be obtained from the publications of trade, technical, and research associations within each industry, and these are listed in a later chapter (see Chapter 6).

As a guide to the American Chemical Industry, the Chemical Economic Services (Princeton, NJ, 08540) has issued a file of corporate diagrams and administrative personnel of the Chemical Industry (1966–7 edition). It includes all chemical companies having annual sales of $25m and over. Also, the fifth edition of *Chemical Guide to the United States, 1967* has been published (Noyes Development Corporation, Noyes Building, Park Ridge, NJ, 07656) and describes the 500 largest US chemical manufacturers.

Departments in Chemical Companies

From the careers viewpoint the chief divisions of a company engaged in chemical manufacture are these:

Production
Research and Development

Sales—Commercial, Technical
Sales—Marketing, Export
Purchasing
Secretarial and Accountancy—General—Costing—Computer
Personnel
Publicity and Public Relations
Transport
Information and Library.

Although each of these divisions of a company requires its own specialized knowledge and skills, and also, of course, the qualifications appropriate to the job and its seniority, a background appreciation of the principles of chemistry is a great help. The books recommended in Chapter 1 will give a first introduction in an interesting and practical way, and also found particularly useful to those without a scientific training will be G. Bruce Macalpine, *Teach Yourself Chemistry* (EUP Ltd., 1963), and L. P. Lessing, *Understanding Chemistry* (Harrap, London, 1961).

Production

Here the emphasis is on chemists, physicists, and chemical engineers, besides the electrical, mechanical, and electronic engineers essential to the running of any manufacturing process. There may also be a need for mathematicians for statistical work and computer control as well as assistance in costing.

These will play their several parts not only in the manufacturing processes themselves (which may contain many individual stages for each product) but also in the introduction of more and more automatic controls and instrumentation. To be in charge of one of the production units—which a qualified young man may well be quite early in his career—one would not only have to study closely the control of the process and the quality of the product, but also develop an acute cost consciousness, and consult with engineering and research colleagues to improve the efficiency of the plant. There is also the absorbing human interest in accepting

responsibility for the welfare and efficiency of the people who work on the plant.

In a chemical factory, as in all factories, at least as important as qualifications, "getting on with people" is a necessary personal attribute, while still maintaining the necessary discipline of the well-knit team whether in senior or junior position.

The graduate may enter the company through any of these departments and undergo a course of training to get accustomed to the routine of the factory. There are also opportunities for younger beginners coming straight from school or college and they would usually take up a junior position in a laboratory whence they would progress in time to senior laboratory positions or to a position on the production plant itself. Training and qualifications are discussed in the next chapter.

Perhaps a word of explanation will be helpful here on the important part played by the chemical engineer in the production of chemicals. This is the most recent of the recognized qualifications and while it used to be said facetiously that a chemical engineer is one who makes his reputation by talking engineering to chemists and chemistry to engineers, this is far from the case today.

The American Institute of Chemical Engineers defines the position thus:

> Chemical engineering is that branch of engineering concerned with the development and application of manufacturing processes in which chemical or certain physical changes of materials are involved. These processes may usually be resolved into a co-ordinated series of unit physical operations and unit chemical processes. The work of the chemical engineer is concerned primarily with the design, construction, and operation of equipment and plants in which these unit operations and processes are applied. Chemistry, physics, and mathematics are underlying sciences of chemical engineering and economics its guide in practice.

There is a useful introduction to the subject especially suitable for students of chemistry or physics, dealing with the fundamentals but not describing plant and machinery, T. K. Ross, *An Introduction to Chemical Engineering* (Pitman, 1953). See also "The Chemical Engineer in Industry" in *Chemical and Engineering News*, **41** (4) 14–18 (28 January 1963).

Two books which give guidance on chemical engineering and provide a background and philosophy for the whole subject of production are J. H. Perry, *Chemical Engineers' Handbook*, 4th edn. (McGraw-Hill, 1963), which is the one absolutely essential reference book and constant technical companion for every chemical engineer, and R. N. Shreve, *Chemical Process Industries* (McGraw-Hill, 1956). Besides being a college textbook this is also a reference book.

A recent addition to the literature of chemical engineering of especial interest is H. C. Bauman, *Fundamentals of Cost Engineering in the Chemical Industry* (Reinhold, New York, 1963).

As a result of the Prime Minister's first National Productivity Conference, a new handbook has been published, *Productivity: a handbook of advisory services* (HMSO, London, 1967).

Research and Development

The idea of research is probably the one most easily grasped by the young man or woman straight from school, college, or university. Where it is research on the synthesis of new organic compounds it has the appearance of being a continuation of his own college laboratory work. The research laboratory is already not unfamiliar to him and the transition from college to industry involves less drastic change than in production or sales or other activities.

The research laboratory is therefore a convenient entrance place for scientists to the Chemical Industry and progress can be made either within the research department or by progressing by experience to positions of responsibility in other spheres. The research laboratory staff will be largely recruited from graduates, but there are also junior positions as assistant chemists and laboratory technicians, and usually "time off" is given such juniors to enable them to attend college courses to attain higher qualifications.

The development function is sometimes a part of the research organization, but frequently it is a separate section. The work

involved is not always so clearly understood by the outsider but its main function is to study new products produced by research and find suitable applications for them. In this study the products may have to be modified to work easily in a given process, or may have to undergo an after-treatment. Another function is to study new applications for existing products. It is a good place for young men of ingenuity who can grasp the conditions of the using industries and visualize just what goes on in the various applications.

Chemical engineers as well as chemists will find a place here (as well as other scientists and craftsmen) and many development departments will include pilot plant (i.e. small-scale plant which is a replica of the production unit) or, if not, the development staff will be expected to take the product with its modifications to the pilot plant attached to the works and see it through its teething troubles.

In all this work on both research and development there are, of course, increasing numbers of positions for biologists, physicists, biochemists, mathematicians, and statisticians, especially where the work deals with the application of chemicals to living matter as in medical and pharmaceutical work, agricultural chemicals, pesticides, and others.

E. S. Hiscocks, *Laboratory Administration* (Macmillan, London, 1956), is a useful introduction to the problems met in research laboratories. It is based on experience gained in the National Physical Laboratory but describes well how the different types of workers and scientists co-operate together to make a research team. Very few books of this authority appear on laboratory management.

Books on the wider aspects of research in industry are C. E. K. Mees and I. A. Leermakers, *The Organisation of Industrial Scientific Research*, 2nd edn. (McGraw-Hill, 1950), and D. B. Hertz, *The Theory and Practice of Industrial Research* (McGraw-Hill, 1950). Both have a good bibliography to that date.

The scope of research in industry in Britain is described in I. D. L. Ball (Ed.), *Industrial Research in Britain*, 5th edn. (Harrap, 1964), which also contains a good deal of relevant information on

training and careers, scientific and technical societies, sources of information, and so on.

When deciding whether or not one has the necessary personal attributes to take up research, a book which assists by discussing the background philosophy and the advantages and drawbacks of such a career is P. Freedman, *Principles of Scientific Research* (Pergamon, Oxford, 1960).

Sales

It is not absolutely essential that salesmen in the Chemical Industry be scientists, but it is becoming more generally the case. It is true there is a flair for selling and an ability for getting on with people which help tremendously in the selling of anything at all, but in the Chemical Industry it is a great asset if the salesman also understands his product as a chemical and can speak of its properties in scientific terms, for he will normally be offering it to a scientifically trained man at some stage of the negotiations. Not all scientists can adapt themselves to the exacting requirements of selling, but to all who feel they have the patience, understanding, and "stickativeness" with a little aggressiveness at the right moment, selling presents a rewarding, adventurous occupation. For the many who can interest the buyer and describe the product fluently there are fewer who can clinch the deal—and this is what is required.

The sales staff is normally supported by a laboratory or laboratories to study and investigate technical problems arising from the use of the company's products in the various industries. Competition is so severe that much work is done to simplify instructions for use. This is the work of the technical service laboratories. These laboratories therefore present an interesting field of work for men who wish to retain their scientific status and continue in such work but requiring also occasional contacts with customers and visits to other works in dealing with technical problems (including "trouble shooting"). The technical service laboratories employ, besides graduates, many young men who have had

experience in industry or have a craft or a skill in their hands, because often much more is required in technical service than pure chemical knowledge.

Of particular interest to the scientifically trained salesman is the export field, for where only limited time can be spent with any individual customer on a visit overseas, the discussion is less personal and is at its best when the product and its application can be described clearly, if possible in the language of the customer, but at least in clear, understandable English. The Institute of Export (Export House, 14 Hallam St., London, W 1) advises on courses of training and is an examining body.

Marketing

The Chemical Industry is a growth industry. Every year new products become available. Some establish themselves on a permanent basis, many have a useful life of a few years before they are superseded by further new products. In a recent American survey it was estimated that 14 per cent of the chemicals sold in 1963 were not on the market in 1959. It is important, therefore, that there should be a marketing section studying these changing markets due to technical improvements or cheaper processes, or new industries and the changing social and industrial environment in general. The positions in this section can well require a certain amount of scientific training but are also open to arts graduates and to men of imagination and initiative from any backgrounds of training so long as they can see the changing circumstances and trends and take appropriate action to adapt their organization to meet the new growing requirements.

As a guide to the scope of this field R. E. Chaddock *et al.*, *Chemical Market Research in Practice* (Chapman & Hall, London, 1956) is useful.

This book was produced by the Chemical Marketing Research Association of the United States, based on a series of lectures designed for students, beginners in market research, and executives seeking wider information. There is a good bibliography.

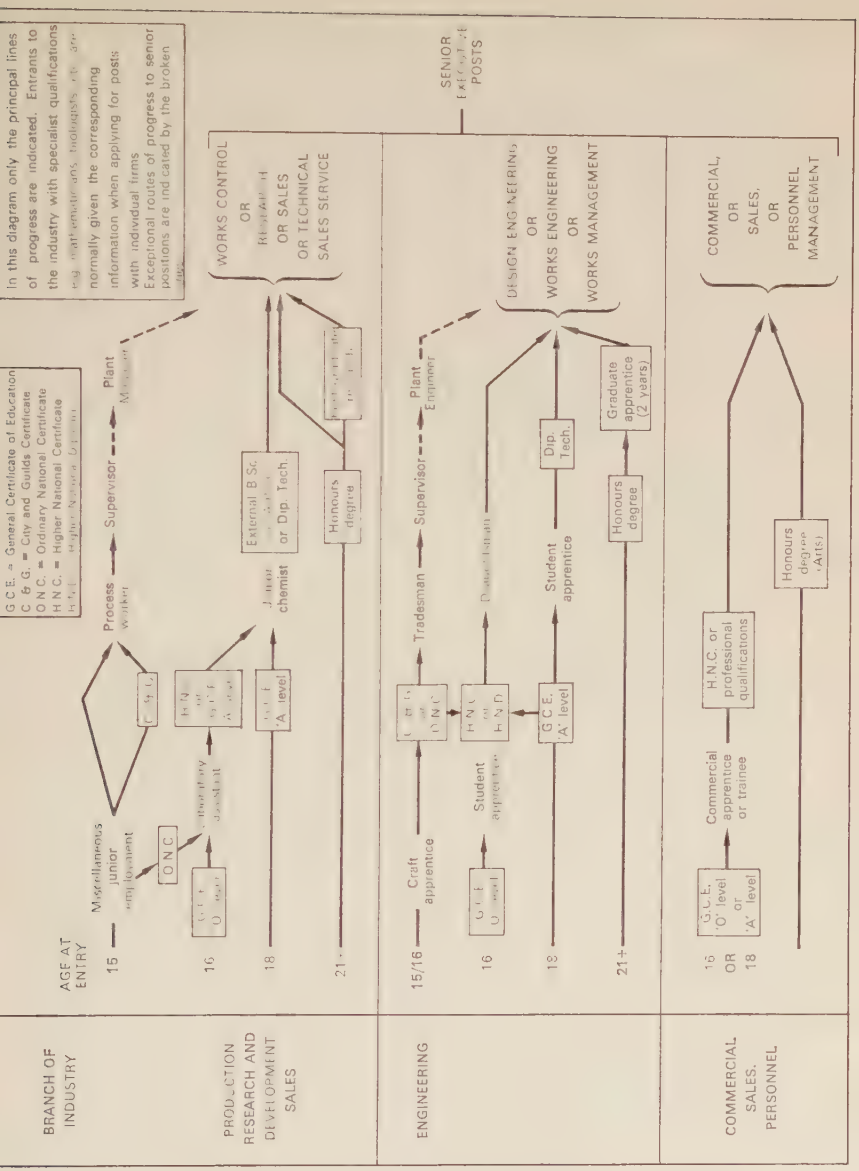


FIG. 1. The Chemical Industry—some typical lines of progress. (By permission of the Chemical Industries Association.)

The chapter on marketing (chapter 1) in Conrad Berenson's *Administration of the Chemical Enterprise* (Wiley, New York, 1962) is suitable for students and for people in the industry seeking greater insight into their problems. There is also a useful bibliography.

In the United Kingdom there is the Industrial Marketing Research Association which has recently held its fourth Annual Conference (Organizer, Mr. D. Ross, John E. Sturge Ltd., 1 Wheeleys Rd., Birmingham, 15), but there has been no public body dealing with chemical marketing until the appearance of the newly formed Chemical Section of EVAF, the European Association for Industrial Marketing Research. At the time of going to press there has not been much opportunity of finding details of the new section, but the Hon. Sec. is Mr. A. C. A. Seinet, British Glues and Chemicals Ltd., 168–73 High Holborn, London, WC 1.

Purchasing

This is an important section of the chemical organization responsible for buying raw materials and intermediate products (besides items of plant and the various other needs of the company) so that very large sums of money are involved. The purchasing officer and his assistants need not be scientifically trained, though obviously it is an advantage to have some knowledge of the nature and properties of the products being purchased. It is their essential business, however, to know the sources of supply and to be on such terms with producers and agents that in times of difficulty they can be assured of supplies at economic terms. They should be sufficiently close to their suppliers so that they can see trends and take adequate action to safeguard the needs of the company. There are openings here, therefore, for young men interested in people as well as in seeing that the needs of the factory are fulfilled on time at economic prices consistent with the quality of the material.

There is a useful guide to practice in Britain, *Purchasing for Industry and Public Undertakings*, edited by F. Kay for the Pur-

chasing Officers Association (1960). Intended in the first place for students it serves also as a source of information for those already in industry. Although not written specifically for the Chemical Industry it gives the principles and practice of purchasing as carried out in a broad cross-section of industry.

The Purchasing Officers Association, Wardrobe Court, 146A Queen Victoria St., London, EC 4, is the professional body whose examinations, leading to corporate membership, are the recognized qualifications for purchasing appointments.

The purchasing department has the assistance of analytical and testing laboratories (usually attached for administrative purposes to the factory) where the raw materials are examined and specifications drawn up to guide the purchasing officer in getting the right quality for the job. The analytical laboratory demands great accuracy of working and appeals to men who get satisfaction from devising accurate yet speedy techniques of analysis and in using these with care and precision. It involves a good deal of routine work, but there are always opportunities for devising more speedy or more accurate methods, or even to make possible certain estimations which previously presented insurmountable difficulties.

The relevant professional bodies are the Society for Analytical Chemistry, 14 Belgrave Sq., London, SW 1, and the Society of Instrument Technology, 20 Peel St., London, W 8.

Secretarial and Accountancy

These departments are, of course, common to all manufacturing enterprises, but the ever-changing nature of production of chemicals, their markets and applications, makes the Chemical Industry an especially exciting and interesting field of accountancy.

Apart from the general accounting to be done, the prompt presentation of monthly and quarterly figures, together with continuous stock totals and costing information, is essential for management to maintain its forward-looking control in this highly competitive industry.

While junior positions are available to school-leavers, senior positions require a qualification in accountancy through the Institute of Chartered Accountants (Moorgate Place, London, EC 2), the Association of Certified and Corporate Accountants (22 Bedford Sq., London, WC 1), or the Institute of Cost and Works Accountants (63 Portland Place, London, W 1). There are also accountant student societies in most big towns and cities which are helpful during study.

The advent of computers into this field opens up a host of new positions now available to young men and women with neat, tidy, and accurate minds. A mathematical training is an advantage, but both science and arts graduates, and also school-leavers, find interesting employment.

The following books give a useful introduction to the general subject of computers:

A. J. Burton and R. G. Mills, *Electronic Computers and their Business Applications* (Benn, London, 1960).

J. H. Levenson (Ed.), *Electronic Business Machines* (Heywood, London, 1959).

R. H. Williams, *The Electronic Office*, 2nd edn. (Gee, London, 1958).

As computers have many other interesting applications in the Chemical Industry a separate chapter (10) has been devoted to the subject.

Personnel

The personnel officer should be qualified in this important subject by examination, and the qualifying body is the Institute of Personnel Management (80 Fetter Lane, London, EC 4). His assistants should at least be studying to obtain some such qualification. They are concerned with the welfare of all employees within the framework of an efficiently running organization. The problem of communication, the understanding of management policy by employees, and the appreciation of personal problems by management at all levels—these are in the hands of the personnel

officer, as well as his more obvious duties in recruitment, selection, education, and training within the company, and wages, administration of salaries, and all such other procedures which make the company a smoothly moving piece of "human machinery".

A very good insight into the complexities of this division can be obtained from the *Personnel Management Handbook*, 3rd ed., edited by H. Griffiths (Business Publications, London, 1963).

Publicity and Public Relations

These two functions are sometimes joined together, sometimes kept separate. The publicity manager deals with the advertising of the company's products, and must therefore be in close contact with technical and sales staff from whom he gets his material, with artists and designers who work out his displays, and with the various newspapers and journals, television, and other media through which he places his advertising. It is a very interesting activity and usually very successfully carried out by men or women holding an arts or commerce degree.

The public relations division presents a true picture—"the public image"—of the company, not only to its customers but to its employers and shareholders, to the public at large, to the locality in which it operates, and to the press. This again is essentially a post for the arts graduate of imagination and high intelligence and a certain artistic appreciation.

Howard Stephenson's *Handbook of Public Relations* (McGraw-Hill, 1960) describes the American scene in this subject and gives much information to those involved in this interesting field.

Further guidance in this field can be obtained from the Institute of Public Relations (Hastings House, Norfolk St., London, WC 2).

Transport

Almost every manufacturing company, besides having its own fleet of lorries and wagons, utilizes outside transport by road, rail, sea, and air. The transport officer must therefore be a man of wide

experience in all these fields, and know how to move a consignment of goods, large or small, from point *X* to point *Y* cheaply and quickly.

A most useful survey of the whole subject of transport in the Chemical Industry is contained in the *Chemical Business Handbook*, edited by J. H. Perry (McGraw-Hill, 1954), in the chapter entitled "Traffic and Transportation". It refers to the United States but the wide scope it covers serves as a guide to the classification of information and equipment in the organization of such a department anywhere.

Information and Library Service

This division of the chemical manufacturing company becomes more and more important every year because everyone concerned with business decisions can now have at his disposal a great deal of accurate information and guidance if only he can retrieve the information quickly at the right time. There is therefore an opening for what are sometimes called "library chemists" or "library scientists", but more properly now information scientists who take pride and pleasure in their knowledge of how and where to locate information of all kinds. Nowadays, not only the scientists have this need but businessmen, commercial and administrative, demand similar help.

Fortunately, with the need there has arisen the provision of courses in librarianship, either as a qualification in itself or as a postgraduate training following a science degree. Schools of librarianship exist in several universities leading to diploma or degree, and in a number of commercial and technical colleges preparing for the examinations of the Library Association (7 Ridgmount St., London, WC 1), from whom details and advice can be obtained.

The Library Association Year Book is a valuable guide to schools of librarianship and to the syllabus leading to the principal examinations, also to correspondence courses and financial assistance grants.

The rapid increase in the growth of scientific information poses new problems beyond the resources of the individual scientist or even the individual organization. For example, it is estimated that there are 3·5 m chemical structures now known, and these are increasing at the rate of nearly 100,000 per year. Quantities of this order can only be handled by computer. To study this situation the Government has set up the Office for Scientific and Technical Information (OSTI) within the Department of Education and Science, and OSTI grants have already been made (1) to Sheffield University to develop techniques for the automatic detection of structural relations among compounds in a computer file (this supplements the work in the United States by the Chemical Abstracts Services); (2) to Leeds University to establish an information centre on the science and technology of high-temperature processes (over 2000°C); and (3) to the Chemical Society's research project at Nottingham University on information dissemination and retrieval. Authorities over the world recognize that information retrieval must be organized on an international basis as soon as possible. The scope of careers in this field is enormous and of course the use of computers in this field is already accepted as essential.

Sometimes the patents department is included in this division as, of course, other people's patents are valuable sources of information on research and development work being carried out in the Industry and it is essential also that the patents officer should know his way about the literature of a wide variety of subjects.

Chapter 6 in Conrad Berenson's *Administration of the Chemical Enterprise* is headed "The Role of Patents in the Chemical Industry" and provides a most useful outline for anyone interested in this particular sphere. See also Chapter 7 on Patents.

Details of training may be obtained from the Chartered Institute of Patent Agents (Staple Inn Buildings, London, WC 1).

In addition to all the foregoing opportunities, the Chemical Industry has also positions to offer medical officers, lawyers, and

other professional and craft specialists. The *Chemical Business Handbook*, edited by J. H. Perry (McGraw-Hill, 1954), contains chapters describing the functions carried out by various specialist departments within chemical manufacture. The fact that these refer, of course, to practice within the United States does not make them any less useful in the United Kingdom as it is the scope and nature of the function which is of particular interest when examining prospects of a career.

Careers

Preliminary Steps

Where school-leavers and graduates or other ambitious young men and women are considering the Chemical Industry as a career, they can take a number of preliminary steps to learn something about the industry before committing themselves.

Such inquiries are most important and it is never too soon to start on them. Much can be learned from books and even more from direct personal contact with people already working in the industry, whether in senior or junior positions.

Vacation Jobs

Many of the larger companies are willing to receive undergraduates into their laboratories, factories, or offices during the long summer vacation, and this experience furnishes an excellent opportunity to get to know the industry from the inside and to compare notes with other young people already in the industry. This facility is frequently extended also to sixth-formers, although their obvious lack of experience restricts their usefulness. Application for such positions can be made direct to the personnel officer of the individual company in which interest has been aroused, or alternatively to the school careers master or the university appointments board, which maintains continuing contact with industry.

Chemical Manufacturers—the Industry

In considering individual companies whether for a career or for a vacation, the following publications of the Association of British Chemical Manufacturers (merged since 1 January 1966 in the new Chemical Industries Association (CIA), Alembic House, 93 Albert Embankment, London, SE 1) give very full information:

British Chemicals and their Manufacturers, and *The Chemical Industry—a Career for You.*

These describe the nature, growth, and work of the industry, and the latter outlines careers available. Names and addresses are also given so that those interested may write for further particulars. In addition to this, the larger companies themselves issue brochures describing opportunities within their own organizations, copies of which may be obtained by application to the respective personnel officers.

See also *A History of the Modern British Chemical Industry* by D. W. F. Hardie and J. Davidson Pratt (Pergamon, Oxford, 1966), which gives a descriptive list of 200 of the most important companies in the Chemical Industry.

Specialized Industries

Similar information can be obtained concerning the specialized chemical industries by approaches for vacation jobs or works visits and by reading the publications of trade and technical associations serving each industry. The information thus available and addresses where it can be obtained are listed under Industry headings in Chapter 6.

General Guidance

At school the careers master should be consulted as the first source of information in conjunction with the youth employment officer of the district.

At university (or college) the university appointments board can give guidance as to opportunities in the Chemical Industry.

Others, over 18 and not at school, can discuss opportunities with their employment exchange.

Four publications will supply a good deal of useful information, although not confined to the Chemical Industry:

C. LABOVITCH, *The Directory of Opportunities for Qualified Men* (Cornmarket Press, London, 1962).

Opportunities for Girls and Women in Science and Technology, published by the British Federation of University Women.

The Directory of Opportunities for Graduates (Cornmarket Press, London).

D. E. WHEATLEY (Ed.), *Industry and Careers* (Iliffe Books, London, 1961).

This last named describes the work of the youth employment service and the professional and executive register of the Ministry of Labour, and the schools and university appointments boards, besides giving in some detail the organization of industry and the qualifications necessary to enter.

FINDING THE SUITABLE POSITION

Having decided on the Chemical Industry as an attractive career and learnt all possible about it before applying for a specific job, a certain amount of personal assessment should take place to suit the personal qualities to the needs of the position available and desirable. This is a most exciting and exhilarating stage of life and should be given the careful consideration it deserves. A very useful and inspiring guide to this type of thinking is contained in "Happiness as a Goal" by C. Pacifico, *Chemical and Engineering News*, **37** (4) 1–13 (26 January 1959), from which Table 3 is taken.

The article is written for the US scene but is equally applicable in the United Kingdom. Besides discussing the preliminary assessment for the job, behaviour in the early years of a new job is also considered with very valuable guidance on how to

TABLE 3. CHECK YOUR TALENTS AGAINST THE NEEDS OF THE JOB

	Verbal Ability	Social Intelligence	Analytical Mindedness	Numerical Ability	Mechanical Interest	Forcefulness	Self-sufficiency	Sociability	Self-confidence	Imagination Resourcefulness	Frustration Perseverance	Supervising	Persuading	Helping Others	Working with Data	Working with Instruments
Teaching	× ×	×				×				×		×		× ×		
Pure Research			× ×		×		× ×		×	× ×	× ×				×	× ×
Commercial Research			× ×		×	×				× ×	×				×	× ×
Applied Research	×	×	× ×		× ×					× ×	×			×	×	× ×
Pilot Plant		×	× ×	×	× ×					×	×	×	×		×	× ×
Design			× ×	× ×	× ×		×			×		×	×		× ×	×
Production	×	×			× ×	× ×		×				× ×	×		×	× ×
Market Research	×	×	× ×	× ×		× ×	×		×	×	×				× ×	
Market Development	× ×	×	×			× ×	×		×	×	× ×		× ×		×	
Sales	× ×	× ×				× ×	× ×	×	× ×	× ×	× ×		× ×	× ×		
Technical Service	×	×	× ×		× ×	×			×	×				× ×		×
Analytical			× ×	×	×		×									× ×
Patents—Law	×	×	× ×						×	× ×			×		×	
Personnel	×	×	×					×					×	× ×		
Purchasing	×	×						×	×	×				×	×	
Accounting			× ×	× ×			×		×							

Column heads originally suggested by Arthur Atkin, psychologist and specialist in aptitude testing. (By permission of *Chemical and Engineering News*.)

achieve success. Emphasis is laid upon the necessity for a regular "stocktaking" of the position held, and the need to broaden experience and knowledge, even if it means study in one's own time, and even if the actual job of the moment is narrowly specialized. Progress usually leads to general management where a broad view and wide experience are essential. This line of thought is very well explained in an article in the *Sunday Times*, 17 July 1966, pp. 48–49, written in collaboration with the Careers Research and Advisory Centre, Cambridge, from which Table 4 is taken.

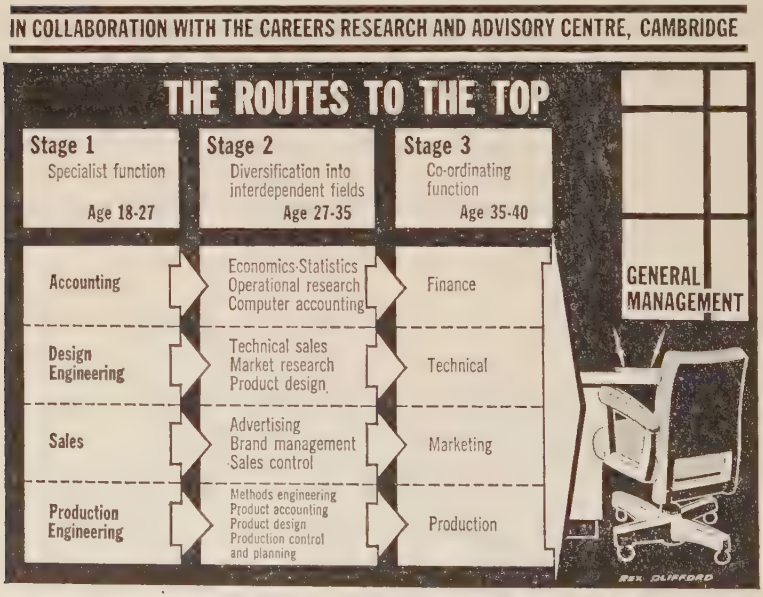


TABLE 4. THE ROUTES TO THE TOP

CHAPTER 3

Qualifications and Training

QUALIFICATIONS and training for chemists are considered fully in a companion book of this series, *How to Find Out in Chemistry* by C. R. Burman (Pergamon, Oxford, 1965). Here is repeated some of that information, but with an emphasis on the technology of the Chemical Industry.

Considering first these questions as they relate to chemists and other scientists in the Chemical Industry it must be said quite frankly that the best positions are open only to those with the highest qualifications, and this means a university degree, and in some cases a higher research degree (Ph.D. or D.Sc.). These can be obtained by full-time attendance at a university, or, with some difficulty and great tenacity of purpose, a London University external degree can be obtained by part-time or sandwich course at a technical college. A "sandwich course" is one in which the student spends a period of some months in each year in a job in industry and the remaining time at college. This has the advantage of retaining close contact with and understanding of the conditions of industry during the years of study.

There is such variety of technical positions in the Chemical Industry that it can absorb graduates and graduate equivalents in almost any of the sciences in addition to chemistry and chemical engineering—physics, biology, mathematics, metallurgy, biochemistry, pharmacology, physiology, and others. By "graduate equivalents" is meant those who take alternative routes to qualifications of about the same high level, namely, to obtain corporate membership of the Royal Institute of Chemistry or the Diploma of Technology—both obtainable by part-time study.

While the highest positions in technology or research in the Chemical Industry usually demand the highest scientific or technological qualifications as above described, it is nevertheless a fact that personal qualities are of the utmost importance. In comparing two men in industry it can frequently be said that one is more highly qualified and more knowledgeable about the subject but that the other is more effective, that is he can get things done. This drive and energy is essential to progress in productivity and is often (but not always) the result of having "come up the hard way", overcoming obstacles in the course of training and study.

Nevertheless, it must be said that the full-time university course has considerable advantages besides enabling the student to gather his information quickly and use it constructively. It helps him to mix with students, teachers, and research-workers in other subjects, which is bound to give him a wider outlook and a broader understanding. It also helps communication, and the facility for expressing his own views clearly and concisely and of appreciating other people's views is a great help in his career. A full-time university course is not the only way of acquiring these attributes—and indeed not everyone acquires them even there—but it is one of the most certain ways.

If, however, for some reason the degree courses by full-time study are not available, it must be said right away that opportunities within the Chemical Industry are still open to school-leavers. By part-time study they can proceed to an external degree of London University, to graduate membership of the Royal Institute of Chemistry, or to a diploma in technology as described above.

At a lower level school-leavers or young men already in the industry in junior positions may elect to make their first efforts to obtain a national or higher national certificate in chemistry or applied chemistry, or other appropriate subject. These certificates do not confer professional status but they represent well-defined standards widely recognized. They can also be used to acquire the habit of study in the early stages and as preliminary steps to obtain the graduate membership of the Royal Institute of Chemistry.

In every laboratory there are positions for laboratory technicians who acquire great skill in performing certain routine tests or in working with highly specialized apparatus or techniques. The industry is beginning to appreciate these acquired skills and is paying reasonable salaries for them. In such positions it is useful to study for the laboratory technicians' certificate of the City and Guilds of London Institute (76 Portland Place, London, W 1). There are two of these—intermediate and final.

The importance of such skilled technicians is becoming more widely recognized, and a discussion has recently been held by the Commonwealth Education Conference on the education and training of technicians (Commonwealth Education Liaison Unit, Marlborough House, Pall Mall, London, SW 1).

There is also a useful book in the Choice of Careers Series from HMSO entitled *Laboratory Technicians and Assistants.*

Whatever the level of study, most companies in the Chemical Industry give young employees day release (one day per week) to attend classes where study is on a part-time basis. Better still, of course, is the sandwich course already mentioned. There is a Ministry of Education publication, *List of Sandwich Courses and Block Release Courses in Further Education Establishments in England and Wales.*

In addition, during the period of training, most companies give an increase in salary to young men on attaining a new and higher qualification.

Degree Courses

Minimum requirements in the general certificate of education (GCE) for the universities are at least two A-levels together with O-levels appropriate to the subject being studied. It is an advantage to have A-levels in chemistry, physics, and mathematics, and in some cases these are required. Particulars of entrance should be sought from the registrar of the university concerned and the calendar of that university carefully studied. The normal course for an honours or special degree takes 3 or 4 years, and fees range

from £20 to £100 per annum. Particulars of grants and scholarships in the British Isles are given in *Grants Year Book*, issued by the National Union of Students (3 Endsleigh St., London, WC 1).

Since the war, owing to the greatly increased numbers of students seeking university degrees, there has been some confusion as to the allocation of places, but now the position is improved partly because of the larger number of places in existing universities and the foundation of new universities, and partly because steps have been taken to co-ordinate the procedure of applications at the various universities. For a guide to universities, colleges, and their courses, and a copy of the booklet *Further Education for School Leavers*, application may be made by postcard to the Department of Education and Science (Room 114), Curzon St., London, W 1. In Wales the address is the Education Office for Wales, Department of Education and Science, 31 Cathedral Rd., Cardiff, and in Scotland the Department of Education, St. Andrews Sq., Edinburgh, 1.

It is possible also to take a degree course by attending certain technical colleges, either full time, part time, or sandwich. Such courses lead to an external degree of London University, and in addition to registering with the college of their choice where their study is done, students must also register with London University as external students for at least 3 years, and they must have A-levels in chemistry, physics, and mathematics. Copies of the regulations can be obtained from the External Registrar, University of London, Senate House, London, WC 1.

Qualification through the Royal Institute of Chemistry

In Great Britain the Royal Institute of Chemistry (30 Russell Sq., London, WC 1) is the professional examining body which registers chemists qualified through its various grades of membership. There are two non-corporate grades—student membership

and graduate membership—and three corporate grades—licentiate, associate, and fellow.

Student membership is open to undergraduates with A-level chemistry, and to part-time or full-time technical college students studying for national certificate.

Graduate membership is awarded on the satisfactory completion of Parts I and II examinations. Holders of a recognized university degree with 1st- or 2nd-class honours in chemistry may be granted graduate membership without further examination. Graduate members may be elected to the associateship (ARIC) after at least 2 years' practical experience.

The fellowship (FRIC) demands high academic qualification, a mature and responsible attitude, and at least 5 years' professional experience. The most recently established corporate grade of licentiateship is for those with lower academic qualifications but still with approved practical experience.

The RIC also publishes *The Training Guide* covering all aspects of their qualifications and courses. The following booklets are also available:

Regulations for Admission to Membership.
Regulations for Admission to Licentiateship.
Study Guide for Graduate Membership Courses.

One of the recent developments within the Royal Institute of Chemistry is the setting up of an Appointments Register for qualified British chemists working overseas but wishing to return to employment in the United Kingdom. The Register will inform UK employers of the qualifications and interest of the chemists overseas and the prospective employer will then communicate direct with any chemist whose qualifications and experience make him of special interest. Similar work is already done by the civil service, the Atomic Energy Authority, and the Central Electricity Generating Board, as well as by one or two of the very largest companies in the Chemical Industry.

Diploma of Technology

This is a qualification in applied chemistry and other technical subjects established in an effort to improve the status of the technology of chemistry *vis-à-vis* the science of chemistry. It was to be advanced by the technical colleges and the colleges of advanced technology rather than the universities, but was in time to carry with it the same status as a university degree. The essential feature of the course is that it is carried out in close contact with industry, preferably by sandwich course or some special arrangement allowing prolonged periods of industrial experience.

The diploma of technology is awarded by the National Council for Technological Awards (24 Park Crescent, London, W 1), who issue the following publications: *Memorandum on Awards Conferred*, which gives details of the diploma and also of the Council's higher award, Membership of the College of Technologists (MCT), and *Memorandum by the College of Technologists on the Award of Membership of the College*.

National Certificates

These are usually obtained by part-time study.

The national certificate in chemistry or applied chemistry is awarded by the RIC and the Ministry of Education and administered by a Joint Committee for National Certificates in Chemistry. Details of courses can be obtained from individual technical colleges. The course for the ordinary national certificate (ONC) lasts 3 years, exemptions for the first two being granted according to performance in the subjects taken in GCE. The third year reaches a standard rather higher than A-level chemistry.

The higher national certificate (HNC) can be taken 2 years after A-level or ONC in chemistry, physics, and mathematics by part-time study only. It is a widely recognized qualification of roughly pass-degree standard. About the same level there is also a higher

national diploma, which is somewhat lower than graduate membership or an honours degree but with a broader basis. Particulars can be obtained from the Secretary, Joint Committee for National Certificates in Chemistry, 30 Russell Sq., London, WC 1).

Laboratory Technicians

There is a tendency in the Chemical Industry in the United Kingdom to have routine laboratory work done by laboratory assistants who are themselves studying by part-time courses to become fully qualified chemists. This means, of course, that the work is done by "lively minded" young men whose incentive to do good work is the knowledge that they are still "on the way up". The disadvantage is that there is not in the laboratory the accumulating experience in techniques and complex apparatus and instruments which results if these exercises are carried out by laboratory technicians—men who are not attracted by the theory of the subject, but who can take great pride in their skill and precision in carrying out laboratory techniques. The continental "laborant" is, in fact, this category of laboratory technician and he is greatly prized.

Boys who are attracted by this work should have a good school standard of English, science, and mathematics. A useful qualification is the laboratory technicians certificate of the City and Guilds of London Institute (76 Portland Place, London, W 1). There are two such certificates—intermediate, a 3-year course in part-time study, and final, requiring 2 more years.

Chemical Engineers

The professional examining body in the United Kingdom is the Institution of Chemical Engineers (16 Belgrave Sq., London, SW 1). The brochures they issue are invaluable:—*Education and Training in Chemical Engineering*, which gives a list of the various

leaflets they issue and includes a summary also of scholarships and courses available in the United Kingdom and *Chemical Engineering: a career*, which explains what chemical engineering is, what a chemical engineer does, and how he is trained.

Membership consists of corporate members in the grades of members (MIChem.E), associates (AIChem.E), and non-corporate members in the grades of graduates and students similar to RIC.

Various courses are open to a school-leaver who decides on a career in chemical engineering in the Chemical Industry:

1. Degree course (3 or 4 years) in chemical engineering with practical experience during vacations.
2. Degree course in chemistry followed by a year's postgraduate study of chemical engineering, followed by some years' practical experience.
3. Full-time or sandwich course at a technical college leading to a diploma in chemical engineering, taking 4 or 5 years. This must be supplemented by practical experience.
4. Apprenticeship with a chemical engineering firm. He can qualify for AIChem.E by first getting ONC in chemistry or mechanical engineering, and then HNC in chemical engineering. These can then be followed up by taking the examinations of the Institution of Chemical Engineers.

There is also a national scheme of training for chemical plant operators up to a technician level which is described in the booklet *Scheme of Training for Qualified Chemical Operators*, issued by the Association of Chemical and Allied Employers who run this scheme. This Association is now merged into the Chemical Industries Association (CIA) (Alembic House, 93 Albert Embankment, London, SE 1).

They also issue another booklet, *A Career in Chemicals*, which describes the work and gives the location of the training centres in the United Kingdom. CIA also issue the book *A Career for You*, from which Fig. 1 is taken.

Other Scientific Professional Qualifications

Mathematicians will get their information on training from *How to Find Out in Mathematics* by J. F. Pemberton (Pergamon, Oxford), also from the Association of Incorporated Statisticians (55 Park Lane, London, W 1); biologists, *Biology as a Career*, published by the Institute of Biology (41 Queen's Gate, London, SW 7); biochemists, *Careers in Biochemistry* and *Training of Biochemists*, both published by the Biochemical Society (20 Park Crescent, London, W 1); and physicists, *How to Find Out in Physics* by B. Yates (Pergamon, Oxford).

Non-technical Qualifications

It is not proposed here to go into the details of training and qualifications in the various non-technical activities of importance to the Chemical Industry. It would be entirely out of place in a book on the Chemical Industry to find a detailed description of the qualifications and training of an accountant or a public relations officer. These find places in all industries.

It may be said in general that the most senior positions require the highest qualifications and it is best to acquire these at the outset of one's career. Junior positions can be held by school-leavers who are prepared by part-time study to gain the requisite qualifications by examination. Details of the accepted qualifications in these professions and of the courses leading to them can be obtained by application to the professional bodies named in the survey of careers in Chapter 2 and in Chapter 5 on Organization.

Grants and Scholarships

Large numbers of scholarships or grants are available in the United Kingdom, many of them covering maintenance as well as tuition fees. It is estimated that about 80 per cent of university students in Britain are now aided from public or private funds.

Guide to Grants available to Students taking First Degree and Comparable Courses is published by the Department of Education

and Science (Curzon St., London, W 1), and useful information can also be obtained from *The Grants Year Book*, issued by the National Union of Students (3 Endsleigh St., London, WC 1). The Department also awards over two hundred technical state scholarships to students. Details are available from schools and colleges and from the Department of Education and Science, Curzon St., London, W 1.

Local authorities award even greater numbers of grants to students with a minimum of two A-level subjects who have a firm offer of a place in a university or technical college.

Sometimes such grants can be augmented by university scholarships obtainable by examination. Details can be obtained from the registrar of the particular university or by a study of the university calendar. In certain cases the Ministry of Education will make up the scholarship or local authority grant to the value of a state scholarship—again details from the registrar.

The Science Research Council (SRC) (State House, High Holborn, London, WC 1) makes postgraduate awards in the following categories, and leaflets are obtainable under these titles:

Industrial Studentships

These are to help young scientists and technologists in industry to obtain postgraduate training in the methods of research or on suitable advanced courses of value to them in their careers in industry. Applications are to be made through the head of the department where the training is to be received.

Industrial Fellowships

This represents a new form of co-operation between the SRC and industry to encourage the further training of scientists and technologists by providing support during the period of training. Employers wishing to propose a member of their staff for an industrial fellowship should write to SRC in the first place.

Science and Industry Awards

These are essentially for graduates who wish first to gain experience in industry before proceeding with their postgraduate studies. Application forms have to be completed by student, employer, and university or college, and may be submitted any time after 1 March in the year in which the candidate expects to graduate.

There is also another guide available, *United Kingdom Postgraduate Awards*, published by the Association of Commonwealth Universities, 36 Gordon Sq., London, WC 1. It contains information about fellowships, scholarships, and grants tenable at universities in the United Kingdom—also a short list of some tenable outside the United Kingdom by UK graduates.

In addition to these official grants many companies in the Chemical Industry have their own training schemes by which industrial training is supplemented by university or college courses with all fees paid in addition to a regular salary. Certain companies and industrial research associations have scholarship schemes of their own. The training guide of the RIC, already mentioned, describes some of these schemes.

CHAPTER 4

Chemical Industry Literature

In this chapter we have excluded that literature which caters for the specialized chemical industries because each of these industries and its literature is dealt with separately in Chapter 6. We will therefore confine ourselves to the published material which is concerned with the Chemical Industry as a whole.

For a concise but comprehensive survey of the literature of the science of chemistry, the reader should refer to C. R. Burman, *How to Find Out in Chemistry* (Pergamon, Oxford, 1965).

Amongst the many general reference works which are of interest to the Chemical Industry the following are outstanding examples:

Beilsteins Handbuch der organischen Chemie, 4th edn. (Springer, Berlin, 1918).

R. E. Kirk and D. F. Othmer, *Encyclopedia of Chemical Technology*, 2nd edn. (Interscience, New York, currently being produced) (Fig. 5).

Thorpe's Dictionary of Applied Chemistry, 4th edn. (Longmans, Green, London, 1937–56) (Fig. 3).

Kingzett's Chemical Encyclopaedia, 9th edn. (Baillière, Tindall & Cassell, London, 1966) (Fig. 4).

A. and E. Rose, *Condensed Chemical Dictionary*, 7th edn. (Reinhold, New York, 1967).

A special place must be reserved for the remarkable *Merck Index of Chemicals and Drugs*, 7th edn. (Merck, Rahway, NJ, 1960) (Fig. 6).

The literature in this chapter should be taken as a guide to the type of material which is available and it should be borne in mind

G SALT, $(NaSO_3)_2C_{10}H_5OH$, is the sodium salt of 2-NAPHTHOL-6, 8-DISULFONIC ACID, prepared by the more complete sulfonation of beta-naphthol than for Schaeffer's salt, followed by neutralization. The white needles are soluble in water and are sold in barrels for the manufacture of intermediates and azo dyes. A paste form is also sold.

R SALT, $(NaSO_3)_2C_{10}H_5OH$, is the disodium salt of 2-NAPHTHOL-3, 6-DISULFONIC ACID prepared from the proper sulfonation of β-naphthol, followed by neutralization with alkali. Dry and paste forms are available in drums for preparation of dyes and intermediates.

SODIUM DIMETHYLDITHIOCARBAMATE, $C_3H_6NS_2NA$, is available as a 41% aqueous solution of a pale yellow-green color. It is used in rubber compounding and in the preparation of tank-mix fungicides.

SODIUM ALGINATE is a salt of alginic acid, derived from seaweed, which dissolves or disperses in water. The composition is indefinite. Grades sold are water-soluble refined and semi-refined in barrels, and white powdered NF grade in drums. It is used as an emulsifying agent in cosmetics and food products, particularly ice cream, and in boiler compounds.

SODIUM LIGNIN SULFONATE is similar in preparation and properties to ammonium lignin sulfonate. The product contains 68-80% of total lignin sulfonates, the remaining constituents being wood sugars. Its uses are similar to ammonium lignin sulfonate. The sodium salt is preferred where ammonia fumes are undesirable. In addition it is preferred as a dispersing agent in the cement, concrete, and oil-drilling mud industries, and as a depressant in flotation of sulfide ores.

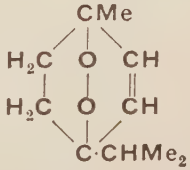
SODIUM CARBOXYMETHYL CELLULOSE is the somewhat indefinite compound usually referred to as CMC. Cellulose is reacted with monochloroacetic acid, more or less purified, and neutralized. Commercial products vary upward in purity from 50%. The fluffy powder is used in cosmetics, soap, and synthetic detergents. It is strongly sorbed on cellulose.

FIG. 2. *Dictionary of Commercial Chemicals* (Snell and Snell), Copyright 1962.
(By permission of D. Van Nostrand Co. Inc.)

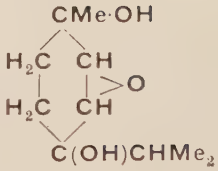
1930, No. 12, 2nd ed.) ; M. A. Peacock, "Nature and Origin of the Amphibole-Asbestos of South Africa" (Amer. Min. 1928, **13**, 241) ; F. E. Keep, Bull. Geol. Survey Southern Rhodesia, 1929, **12** ; 1930, **16** ; L. Reinecke and L. McClure, "Amosite Asbestos" (Trans. Geol. Soc. South Africa, 1934, **36**, 29).

India.—A. L. Coulson (Mem. Geol. Survey India, 1934, **64**, 143). L. J. S.

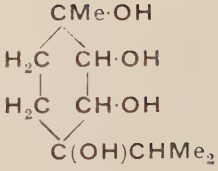
ASCARIDOLE.



The important anthelmintic, chenopodium or wormseed oil, from *Chenopodium ambrosioides* (var. *anthelminticum*, Gray) has as its pharmacologically active constituent the dioxide, *ascaridole*, b.p. 96°–97°/8 mm., $d_{20°}^{20°}$ 0·9985, $n_D^{20°}$ 1·4769, $[\alpha]_D$ +0·7°. Ascaridole was first isolated by Hüthig (Schimmel's Report, 1908, April, p. 108) and its structure was elucidated by the investigations of Nelson (J. Amer. Chem. Soc. 1911, **33**, 1404 ; 1913, **35**, 34) and of Wallach (Annalen, 1912, **392**, 59). The



(VI)



(VII)

be smoothly effected by heating the peroxide in a neutral solvent (xylene) (Henry and Paget, J.C.S. 1921, **119**, 1722). On hydration with sulphuric acid ascaridole glycol anhydride gives two isomeric *glycols* (V), m.p. 62·5°–64° and (VI), m.p. 103°–105°, and an *erythritol* (VII), m.p. 128°–130°. No crystalline derivatives of ascaridole have been prepared. J. L. S.

ASCLEPIAS COTTON. *Vegetable Silk.* The long, lustrous, but brittle fibres, seed hairs, of *A. syriaca* and *A. incarnata* are used for upholstery in the United States, but cannot be spun to a satisfactory thread. The best fibres of *A.* species have been used for cordage in India and South America.

***l*-ASCORBIC ACID, $C_6H_8O_6$**, is vitamin C, or the antiscorbutic vitamin.

Scurvy—vitamin C deficiency—characterised by its typical hæmorrhages, has long been known to arise from the use of diets deficient in fresh foods and to be readily curable by raw

FIG. 3. *Thorpe's Dictionary of Applied Chemistry.*
(By permission of Longmans, Green & Co. Ltd.)

heated out of contact with air it forms black stannous oxide. It is used in dyeing and textile printing.

Stannous Tartrate is a heavy, white, crystalline compound, soluble in water; it is used in the textile industry.

Organotin Compounds are used as stabilisers for plastics and as fungicides and insecticides. They are relatively stable compounds and the tin may be bivalent or quadrivalent. The SnR_2 compounds are prepared from the Grignard reagent and stannous chloride and the more stable SnR_4 compounds are obtained from the same reagent and stannic chloride. The alkyl and aryl tin halides R_3SnCl, R_2SnCl_2, $RSnCl_3$ are made by the redistribution reactions of SnR_4 and $SnCl_4$. Tin tetraethyl is a colourless liquid, b.p. 181° C.

(References: *Tin and its Alloys*, ed. E. S. Hedges; Arnold, London. *Tinplate*, by W. E. Hoare and E. S. Hedges; Arnold, London. *Organometallic Compounds*, by G. E. Coates; Wiley, New York.)

TINCTURES — Alcoholic preparations, usually of vegetable drugs, made by extraction of the crude drug, or by dilution of a liquid extract. (See Extracts.)

TITANIUM (Ti) and its Compounds — At. no. 22. At. wt. 47·90. M.p. 1,725° C., b.p. 3,260° C. Hexagonal, $a = 2{\cdot}95$ Å., $c = 4{\cdot}73$ Å. The naturally occurring isotopes are of mass 45·9 (7·9%), 46·9 (7·3%), 47·9 (73·9%), 48·9 (5·5%), and 49·9 (5·3%). The electronic configuration is K, L, $3s^2$, $3p^6$, $3d^2$, $4s^2$. The metallic radius is 1·45 Å. The element was discovered in 1789.

Titanium occurs plentifully in several mineral forms: as the oxide (TiO_2) in *Anatase*, *Brookite*, and *Rutile*, and in other forms in *Ilmenite*, *Titanite*, and *Titano-columbates*; it is also present in Nile silt. There are no large deposits in Great Britain. Deposits of *Rutile* exist in Norway, U.S.A., Tasmania, and Australia, and are marketed in the form of black concentrates containing 93–98% TiO_2. Titaniferous iron-ore is found in quantity in the Adirondack Mountains in the U.S.A. Titanite (also known as *Sphene*) is a calcium titanium silicate (CaO,TiO_2, SiO_2; monoclinic, sp. gr. *ca.* 3·5), which occurs in certain igneous and metamorphic rocks.

Rutile and ilmenite ($FeTiO_3$) are found in Eastern Canada, New York, Virginia, North Carolina, and Florida. Ilmenite also occurs in Tasmania and Madagascar, but the largest deposits occur in Quebec and Norway. A deposit associated with uranium exists at Olary in South Australia, and is used as a source of radium and titanium oxide.

Ilmenite, containing *ca.* 34–44% TiO_2, is chiefly used in the manufacture of ferro-titanium alloys, electrodes for arc-lamps, and titanium oxide pigment. Rutile is used in the preparation of titanium compounds and sometimes to give a yellow colour to porcelain.

The large-scale production of titanium involves the reduction of

FIG. 4. *Kingzett's Chemical Encyclopaedia.*
(By permission of Baillière, Tindall & Cassell Ltd.)

1,3-Dibromo-5,5-dimethylhydantoin has achieved its principal utility as a brominating agent. It is capable of at least four types of reaction, namely, allylic bromination, hydrobromination, substitution of active hydrogen, and oxidation of secondary alcohols (38). For a review in this field, see reference (39). Among the substances which have been successfully brominated with 1,3-dibromo-5,5-dimethylhydantoin are ketones, which form α-bromoketones; unsaturated compounds, such as cyclohexene, which undergo bromination in the allylic position to give 3-bromocyclohexene; hydrocarbons, dihydric phenols or phenyl ethers, which undergo nuclear substitution by bromine; butyl rubber, which undergoes addition of bromine to its double bonds; and aralkyl compounds, which undergo side-chain bromination; in the latter case, the presence of benzoyl peroxide is also necessary.

1,3-Dibromo-5,5-dimethylhydantoin may be stored for long periods without appreciable decomposition, if it is protected from moisture and light. It is irritating to the skin and mucous membranes, and therefore respirators, goggles, and rubber gloves are recommended for personnel in contact with it. Stoneware, glass, or glass-lined equipment is recommended for handling it.

1,3-Dibromo-5,5-dimethylhydantoin is commercially available under the name Dibromantin (registered trade name of Arapahoe Chemicals, Inc., Colo.). It is shipped in amber glass bottles, and fiber drums with polyethylene liners. Its price (1965) is $1.70/lb in 10-lb lots or $1.40/lb in 2000-lb lots.

1,3-Dichloro-5,5-dimethylhydantoin. The mp of this substance has been recorded as 131–132°C (40); 132–133°C (41); and 130–133°C (42). The 1-monochloro derivative melts at 143–145°C (37) or 143°C (40). The infrared spectrum of 1,3-dichloro-5,5-dimethylhydantoin shows a characteristic absorption, probably an N–Cl stretching frequency, between 762 and 803 cm^{-1} (43). 1,3-Dichloro-5,5-dimethylhydantoin is readily soluble in most organic solvents and may be recrystallized from chloroform; it is slightly soluble in hot water and is decomposed by prolonged refluxing. The dichloro derivative may be prepared in almost quantitative yield by passing chlorine through a 5% solution of 5,5-dimethylhydantoin, in 6% aqueous sodium carbonate solution (41).

5,5-Dimethylhydantoin and also its dichloro derivative have been synthesized from acetone, ammonium carbonate, sodium cyanide, and chlorine (42). The storage stability of dichlorohydantoin is claimed to be improved, and its melting point raised and sharpened, by dissolving in concentrated sulfuric acid, filtering from inorganic salts and other impurities, and recovering the dichlorohydantoin by dilution with water (44).

1,3-Dichloro-5,5-dimethylhydantoin has been used with some success as a chlorinating agent in organic synthesis. Among the substances which have been chlorinated in moderate to good yields are anthracene, thiophene, phenol, acetanilide, anisole, 1- or 2-acetamidonaphthalene, and 1- or 2-methoxynaphthalene (45). In the presence of light or dibenzoyl peroxide, acetone, butanone, or cyclohexanone may be chlorinated in about 50% yield (46); dimethylaniline has been chlorinated (47) and also butyl rubber.

1,3-Dichloro-5,5-dimethylhydantoin decomposes rapidly in water at pH 9, giving mainly 1-chloro-5,5-dimethylhydantoin, *N*-chloroisopropylamine, chloride ion, nitrogen, and carbon dioxide (48).

The bactericidal and disinfecting action of 5,5-dimethyl-1,3-dichlorohydantoin has been studied widely and also utilized commercially. It is a powerful bactericide and sporicide, and has been used extensively as a germicide or sanitizer in laundries

FIG. 5. Kirk–Othmer's *Encyclopedia of Chemical Technology*.
(By permission of John Wiley & Sons Ltd.)

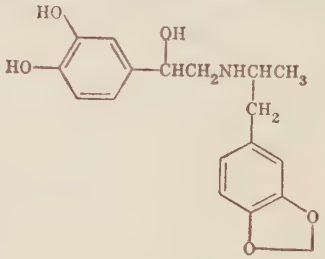
Javanine. From bark of *Cinchona calisaya* Wedd. var. *javanica* and *C. officinalis* L. (*C. ledgeriana* Moens), *Rubiaceae.*

Rhombic leaflets. Soluble in water or alcohol, freely in ether.

Ref. Hesse, *Ber.* **10,** 2162 (1877).

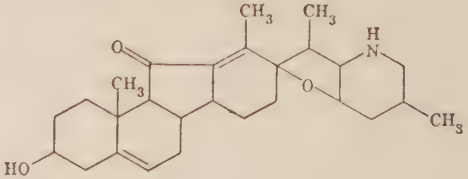
Javelle Water. A soln. of chlorinated potash. When freshly prepared contains about 2.5% active chlorine.

JB-251. *N*-[2-(3,4-Methylenedioxyphenylisopropyl)]norepinephrine hydrochloride; α-[(α-methyl-3,4-methylenedioxyphenethylamino)methyl]protocatechuyl alcohol; Caytine. $C_{18}H_{22}ClNO_5$; mol. wt. 367.84. C 58.78%, H 6.03%, Cl 9.68%, N 3.81%, O 21.75%, HCl 9.91%. Prepn.: Biel, Schwarz, Sprengeler, Leiser, Friedman, *J. Am. Chem. Soc.* **76,** 3149 (1954). Biel, U.S. pat. **2,900,415** (1959 to Lakeside Labs.).



Crystals from isopropanol, m. 126–127°. Soluble in

vised structure: Fried, Wintersteiner, Moore, Iselin, Klingsberg, *J. Am. Chem. Soc.* **73,** 2970 (1951). *Review:* Wintersteiner in Graff, *Essays in Biochemistry* (Wiley, New York 1956), pp. 308–321; *idem, Festschrift Arthur Stoll* (Basel 1957), pp. 166–176.



Needles from methanol + water. m. 241–243° (decomp., heated microstage, Seiferle); m. 243 244° (corr. decomp., Poethke); m. 243.5 244.5° (Saito). $[\alpha]_D^{23}$ −158.5° (c = 0.99 in ethanol, Seiferle); $[\alpha]_D^{20}$ −160.1° (c = 0.75 in 10% acetic acid, Seiferle); $[\alpha]_D^{20}$ −154.5° (ethanol, Poethke); $[\alpha]_D^{20}$ −167.6° (chloroform, Poethke); $[\alpha]_D^{20}$ −150° (ethanol, Saito). LD_{50} i.v. in mice: 9.3 mg./kg. Hydrochloride, m. 300–302°; nitroso derivative m. 250–254° (decomp.); picrate, $C_{27}H_{39}NO_5.C_6H_3N_3O_7$, darkens at 210°, chars without melting at 274–284°.

Jesaconitine. $C_{35}H_{49}NO_{12}$; mol. wt. 675.75. C 62.20%, H 7.31%, N 2.07%, O 28.41%. From root of *Aconitum sachalinense* F. Schmidt., *Ranunculaceae.*

White, amorphous powder. Decomposes at about 130°. Soluble in ether or dil. acids. The perchlorate

FIG. 6. The *Merck Index.* (By permission of Merck & Co. Inc.)

that in the space available it is not possible to include all the germane literature of all the countries of the world which have a chemical industry. We have divided the chapter into the following sections: Abstracts; Periodicals, British and Overseas; Guides; Directories.

Abstracts

An abstract is a short account of a paper giving:

1. The full title.
2. The author's name and address.
3. A summary of the contents.
4. A detailed reference to the journal in which it appeared.

Naturally some abstracts give more detail than others. There are some publications which give only the title of the paper, the author's name, and the name of the journal, and these are called indexes.

Abstract journals and indexes are usually published frequently and so they enable the user to keep himself aware of recent and current work without having to attempt to read all the original papers. They are probably most used in order to conduct literature searches.

Of the more general abstracting journals, *Chemical Abstracts* (American Chemical Society, Easton, Pa., twice a month) is probably the most important in the world. It is followed by *Chemisches Zentralblatt* (Akademie Verlag, Berlin, weekly), which is more detailed than *Chemical Abstracts* and quicker with items from the communist countries. In Britain the *British Technology Index* (Library Association, London, monthly), lists subject-headings alphabetically, whilst in the United States the *Applied Science and Technology Index* (Wilson, New York, monthly) and *Engineering Index Monthly Bulletin* (Engineering Index, New York, monthly) cover many periodicals of interest to the Chemical Industry. *Chemical Titles* (American Chemical Society, Easton, Pa., fortnightly) and *Current Chemical Papers* (Chemical Society, London,

monthly) both provide a fast indexing service of chemical and chemical engineering papers. Because of the minimal delay with which their information is published these and similar publications are called "current awareness" publications.

In the USSR *Referativnyi Zhurnal Khimiya* (Institute of Scientific and Technical Information, Moscow, D-219, twice-monthly) has similarities to both *Chemical Abstracts* and to *Chemisches Zentralblatt*, and for non-Russian readers an English-language edition is published by the Office of Technical Services, Washington.

In France the *Bulletin signaletique* (Centre National de la Recherche Scientifique, Paris, monthly) has two sections which are of special interest to the Chemical Industry; they are *Fascicule 7* on pure chemistry and *Fascicule 8* on applied chemistry and metallurgy. These two sections publish some 50,000 abstracts per year between them.

Very many periodicals contain abstracts of particular interest to their readers, for example *Angewandte Chemie*, *British Chemical Engineering*, and *Journal of the Institute of Petroleum*, to name only a few. Probably the best guide to abstracts and indexes is the *Guide to the World's Abstracting and Indexing Services in Science and Technology* (National Federation of Science Abstracting and Indexing Services, Washington).

Periodicals

There are many types of periodicals of particular interest to the Chemical Industry; they are, in general, published by:

1. Learned societies, and hence deal with fundamental research.
2. Technical and trade associations, and deal with technical and technology matters.
3. Commercial publishers, and deal mainly with industrial news and also contain many useful pages of advertisements.

One of the most comprehensive directories of periodicals of all types is the *Union List of Serials in Libraries of the United States and Canada* (Wilson, New York) (Fig. 7), and also *Ulrich's*

CHEMICAL and process engineering and atomic world. Calcutta; London.
1, Ap 1920+
1920–Mr 1937 as Indian and eastern druggist; Ap 1937–S 1941, Indian and eastern chemist; O 1941–D 1943, International export chemist (varies slightly); 1944–45, International chemical and export industry; 1946–47, International industry; 1948–Mr 1952, International chemical engineering and processing industries (varies slightly). Absorbed Atomic world Ag 1949

DA ns[24]+
IaU [21-23]
MdU-B [20-24]
NN 22+

NNN [1-2]-[4,7]
OCl 22+

InLP 20,1939+
MBP [20-22]
OCl 23,1942+
ScCM [21-22]

PPC [9]
WU 1+

CHEMICAL bulletin. (American chemical society. Chicago section) 1,O 1914+
1914-Je 1919 as Chicago chemical bulletin
CSt [6,17-19]
CSt-L [6-8,18-19]
CU [10]+
DGS [11]
DLC [2]-[5]+
FU [22-23]
ICA [18-20]-[24]+

IaGG 6-[8]9
InNU [12-22]+
KAS [24-25]
KPT 9-10
MCM 8+
MdBE 16+
MiD [12]+

GA 19+
GAT 19+
GEU [16-45]
GU 2-[34-43]+
GU-A 24+
H 45+
I 20+
IC 12-24
ICA 1+
ICD 38+
ICF 1+
ICJ 1+
ICL [2-5,21-22,40-41]
ICU 1+
ICW 1+
IEN 9+
INS 19+
IRA [40]+
IU 1+
Ia 16+
IaAS [1-3]+
IaCfT 26+
IaDm [38-39,44]+
IaDmD 32-[36-37]-40
IaGG 21,25-31
IaU 2+
IdU 1+
InGD 1+
InI 1+
InLP 12+
InU 1+
KAS [20-23]32+
KMK 2+
KPT 25+
KU 1+
KWi [25-36]+

KyL 8+
KyLU 18+
KyU 7-12,14+
LNHT 1+

NbU 5+
NcD 3+
NcRS 2,4-12,14+
NcU 1+
NdU 10-25,27+
NhD 11+
NhU 2+
NjHoS 4+
NjP 1+
NjR 1-2,4+
NjT 2+
NmScS 18-22,24+
NmU [28+]
NvU [6,13-45]
OAU 4+
OC 1+
OCL 8+
OCU 1+
OCX 42+
OCl 1+

OClW 1+
ODW 16-44
ODa 16+
OMC [12-16]+
OO 1-[11-12,14]+
OOxM 2+
OT [8-10]+
OU 1+
OY 19+
OkS 1+
OkT 30+
OkTU 17+
OkU 7+
OrCA 1-2,5+
OrP 1+

OrPR 13+
OrPU [13-15]-25
[43]+
OrU 1+

FIG. 7. The *Union List of Serials in Libraries of the United States and Canada*, 3rd edn.
(By permission of the H. W. Wilson Co., New York.)

Periodicals Directory (Bowker, New York) is very important in this field. There are two directories of chemical journals which are outstanding: (a) *Periodica Chimica* (Akademie Verlag, Berlin) and (b) *List of Periodicals Abstracted by Chemical Abstracts* (American Chemical Society, Easton, Pa.), which is published every 5 years and has annual supplements for the intervening years.

Perhaps the best guide to Soviet periodicals is the *Monthly List of Russian Accessions* (Library of Congress, Washington). A useful list of translations of Russian journals is given in C. R. Burman, *How to Find Out in Chemistry* (Pergamon, Oxford, 1965).

Most of these are held by the National Lending Library.

British Periodicals

In Britain, *British Chemical Engineering* (Heywood, London, monthly) has several regular features which are typical of these journals; they include book reviews, processes, equipment, patents, abstracts, and so on. Similarly, *Chemical and Process Engineering* (Grampian, London, monthly), *Chemistry and Industry* (Society of Chemical Industry, London, weekly), *Chemical Age* (Benn Bros, London, weekly), and *Chemical Processing* (Tothill, London, monthly) all cover their respective fields in a similar way.

On a somewhat different level, the *Journal of Applied Chemistry* (Society of Chemical Industry, London, monthly) and the *British Journal of Applied Physics* (Institute of Physics and Physical Society, London, monthly) publish original papers and abstracts in their respective fields. *The Chemical Engineer and Transactions of Institution of Chemical Engineers* (Institution of Chemical Engineers, London, 10 issues per year) publishes technical papers and also contains news of a more general nature, as does the *Biochemical Journal* (Biochemical Society, London, monthly). A highly specialized journal with an international flavour is *Chemical Engineering Science* (Pergamon, Oxford, monthly), which includes technical papers from all over the world and also a selection of

Soviet topics. The following publication is particularly worthy of note: *Reports on the Progress of Applied Chemistry* (Society of Chemical Industry, London, annually).

Needless to say there are many miscellaneous publications for an industry as large as the Chemical Industry and the following are only a small representative sample:

Chemical Industry Directory and Who's Who (*Chemical Age*, Benn Bros., London, annually) (Fig. 9).

Chemistry and Industry Buyers' Guide (Society of Chemical Industry, London, annually).

Where to Buy Everything Chemical (Where to Buy, London, twice per year).

Chemical Manufacturers and Soapmakers' Directory (Franey, London, annually).

Chemical Worker (Chemical Workers Union, London, alternate months).

Overseas Periodicals

Of the very many American periodicals for the Chemical Industry, the American Institute of Chemical Engineers, New York, publishes the following:

American Institute of Chemical Engineers Journal (every two months).

Chemical Engineering Progress.

International Chemical Engineering.

The American Chemical Society, Easton, Pa., publishes the following:

Industrial and Engineering Chemistry (I and EC, monthly).

I and E Process Design and Development.

I and EC Fundamentals.

I and EC Product Research and Development

Journal of Chemical and Engineering Data.

Specializing in articles and news for the chemical process industries is *Chemical Week* (McGraw-Hill, New York, weekly). There

are many American journals for the specialized industries which are given in *Ulrich's Periodicals Directory* (Bowker, New York). An excellent picture of the industry in the United States can be obtained from *Chemical and Engineering News* (American Chemical Society, Easton, Pa., weekly), and more especially from *Facts and Figures for the Chemical Process Industries* (American Chemical Society, Easton, Pa., annually).

In Germany, *Chemie-Ingenieur-Technik* (Verlag Chemie, Weinheim, monthly) and *Chemische Industrie* (Verlag Handelsblatt, Dusseldorf, monthly) cover advertising, book reviews, patents, statistics, and so on. In addition, *Angewandte Chemie* (Verlag Chemie, Weinheim, monthly) is also published in English in an international edition; it includes technical and research papers, comments, and book-reviews.

In France one of the main journals for the Chemical Industry is *Chimie et Industrie* (Société de Productions Documentaire, Paris, monthly), and *Annales de Chimie* (Masson, Paris, bimonthly) includes much applied chemistry, news of conferences, and so on. The *Bulletin de la Société Chimique de France* (Masson, Paris, 10 issues per year) is mainly concerned with pure chemistry.

It is not proposed to list in detail all the possible periodicals of the Chemical Industry for every country, but perhaps the following will serve to illustrate the point that in general, wherever there is a thriving Chemical Industry, there are periodicals to cater for it.

In Canada there is the *Canadian Journal of Chemical Engineering* (Chemical Institute of Canada, Ottawa, bimonthly).

In the USSR the following are published:

Khimicheskaya Promyshlennost (*Chemical Industry*) (monthly), Khimiya, Moscow.

Kholodil'naya Tekhnika (*Refrigeration Technology*) (bimonthly), Science Research Institute of Refrigeration Industry of USSR, Moscow.

Plasticheskie Massy, Goskhimizdet, Leningrad (English translation published monthly under the title *Soviet Plastics*) (Rubber and Technical Press, London).

	En:	De:	Es:
	glost firing *(ceram.)*	Glasurbrand *m*, Scharffeuer *n*	cocción *f* de vidriado
5153	Glover acid	Gloversäure *f*	ácido *m* de Glover
5154	Glover tower (H_2SO_4 *industry)*	Gloverturm *m*, Denitrierturm *m*	torre *f* de Glover
5155	glowing	Glühen *n*; Glimmen *n*	incandescencia *f*
5156	gluconic acid $C_5H_6(OH)_5COOH$	Glukonsäure *f*	ácido *m* glucónico
5157	D-glucose $C_6H_{12}O_6$	D-Glukose *f*, Traubenzucker *m*, Dextrose *f*	d-glucosa *f*, dextrosa *f*
5158	glucosidases *pl (biochem.)*	Glykosidasen *fpl*	glucosidasas *fpl*
5159	glucuronic acid $COOH(CHOH)_4CHO$	Glukuronsäure *f*	ácido *m* glucurónico
5160	glue	Leim *m*	cola *f*
5161	glue *v*	leimen	encolar
5162	glue cooker	Leimsieder *m*	caldera *f* para cola
5163	glue stock *(tann.)*	Leimleder *n*	recortaduras *fpl* de piel (de que se hace cola)
5164	glue tester	Leimspindel *f*, Leimprober *m*	probador *m* de cola
5165	gluing	Verleimung *f*	encolado *m*
5166	gluside $C_6H_4CO{\cdot}NH{\cdot}SO_2$	Saccharin *n*, *o*-Benzoesäuresulfimid *n*	sacarina *f*
5167	glutamic acid $COOH(CH_2)_2CH{\cdot}{\cdot}(NH_2)COOH$	Glutaminsäure *f*, α-Aminoglutarsäure *f*	ácido *m* glutámico
5168	glutamine $H_2NOC(CH_2)_2CH{\cdot}{\cdot}(NH_2)COOH$	Glutamin *n*	glutamina *f*
5169	glutaric acid $HOOC(CH_2)_3COOH$	Glutarsäure *f*	ácido *m* glutárico
5170	glutathione $C_{10}H_{17}O_6N_3S$	Glutathion *n*	glutatión *m*
5171	gluten	Gluten *n*, Kleber *m*	gluten *m*
5172	gluten glue	Kleberleim *m*	cola *f* de gluten
5173	glutin	Glutin *n*	glutina *f*

FIG. 8. *Dictionary of Chemistry and Chemical Technology in Six Languages.*

Fr:	Pl:	Ru:	
cuisson *f* complète, cuisson *f* de poterie émaillée	wypalanie *n* ze szkliwem	политый обжиг *m*	5152
acide *m* (provenant) du Glover	kwas *m* siarkowy glowerowy	гловерная серная кислота *f*, башенная серная кислота *f*	5153
tour *f* de Glover	wieża *f* Glovera, wieża *f* denitrująca	денитрационная башня *f*	5154
incandescence *f*	żarzenie *n*; żarzenie *n* się	накал *m*; тление *n*	5155
acide *m* gluconique	kwas *m* glikonowy	глюконовая кислота *f*	5156
α-*d*-glucose *m*, dextrose *m*, sucre *m* de raisin	D-glikoza *f*, cukier *m* gronowy, dekstroza *f*	D-глюкоза *f*, виноградный сахар *m*	5157
glucosidases *fpl*	glikozydazy *fpl*	глюкозидазы *fpl*	5158
acide *m* glucuronique	kwas *m* glukuronowy	глюкуроновая кислота *f*	5159
colle *f*	klej *m*	клей *m*	5160
coller	kleić	клеить	5161
bouilleur *m* de colle	warnik *m* do kleju	клееварка *f*, клееварочный котёл *m*	5162
carnasses *fpl*, débris *mpl* cornés de peau	klejówka *f*, odzierki *pl*	клейдающие отходы *pl*	5163
aréomètre *m* à colles	klejomierz *m*	клеемер *m*	5164
collage *m*	klejenie *n*	проклейка *f*	5165
saccharine *f*, imide *m* orthosulfobenzoïque	sacharyna *f*, imid *m* kwasu *o*-sulfobenzoesowego	сахарин *m*, сульфимид *m* *o*-бензойной кислоты	5166
acide *m* glutamique	kwas *m* glutaminowy, kwas *m* α-aminoglutarowy	глутаминовая кислота *f*, α-аминоглутаровая кислота *f*	5167
glutamine *f*	glutamina *f*	глютамин *m*	5168
acide *m* glutarique	kwas *m* glutarowy	глутаровая кислота *f*	5169
glutathion *m*	glutation *m*	глютатион *m*	5170
gluten *m*	gluten *m*	клейковина *f*	5171
colle *f* de gluten	klej *m* glutenowy	клейковинный клей *m*	5172
glutine *f*, gélatine *f* animale	glutyna *f*, żelatyna *f* zwierzęca	глютин *m*	5173

(By permission of Pergamon Press Ltd.)

Kauchuk i Rezina (*Soviet Rubber Technology*) (English translation published monthly by Rubber and Plastics Research Association, Davies House, 69 High Street, Croydon).

For Europe as a whole the *European Chemical News* (Temple Press, London, weekly), gives good coverage.

Japan has a large and expanding chemical industry and the following are some of her better known journals:

Bulletin of the Chemical Society of Japan (Chemical Society of Japan, Tokyo) in English.

Journal of the Chemical Society of Japan (Chemical Society of Japan, Tokyo) in Japanese.

Chemical Engineering (Society of Chemical Engineers, Tokyo, monthly).

Monthly Bulletin of the Japan Chemical Industry (Japan Chemical Industry, Tokyo, monthly).

Chemistry and Chemical Industry (Chemical Society of Japan, Tokyo, monthly).

For further detailed information about world Chemical Industry journals the reader is referred to the directories of periodicals mentioned at the beginning. This brings us to the translation problem which is associated with most foreign-language literature. Many translations are published and an excellent summary of the main publishers of translations is given in B. Yates, *How to Find Out in Physics* (Pergamon, Oxford, 1965, pp. 46–7). In addition, the National Reference Library of Science and Invention (Holborn Division, 25 Southampton Buildings, Chancery Lane, London, WC 2) acquires each year over 15,000 translations of foreign articles and books. It helps readers in several ways with translations and full details are given in its publication *Aids to Readers No. 1*. It is planned to have translators available in order to help those who use the library to make full use of literature written in foreign languages.

Guides

Many theses for higher degrees are an important source of information, yet in many cases they exist only in the library of the institution where the research was carried out. In Britain the *Index to Theses accepted for Higher Degrees in the Universities of Great Britain and Ireland* (Aslib, London, annually) covers the subject thoroughly and in the United States *Doctoral Dissertations accepted by American Universities* (Wilson, annually) is equally useful.

Forthcoming theses can be surmised from *Scientific Research in British Universities and Colleges*, 2 vols. (HMSO, London, annually) and *Directory of Graduate Research* (American Chemical Society, Easton, Pa., annually). The equivalent publication in France is the *Catalogue des Thèses et Écrits Académiques* (supplement to the *Bibliographie de la France*) (Ministry of National Education, Paris, annually) and in Germany the *Jahrverzeichnis der Deutschen Hochschulenschriften* (Deutsche Bucherei, Leipzig, annually). In the USSR the situation has varied over the years and the following article discusses the various publications which have recorded the publication of dissertations in the past and those which do so currently: E. Buist, "Soviet dissertation lists since 1934", *Library Quarterly* (*USA*), **33** (2), 192–207, April 1963.

We turn now to guides to bibliographies which are particularly important because of the time they save when a literature search is made. Two of the most useful to the Chemical Industry are *Searching the Chemical Literature* (No. 30 of the Advances in Chemistry Series) (American Chemical Society, Easton, Pa.) and *Literature Resources for Chemical Process Industries* (American Chemical Society, Easton, Pa.). The following are more particularly devoted to chemistry: R. T. Bottle, *Use of the Chemical Literature* (Butterworths, London, 1962), and N. Gaudenzi, *Guida Bibliografia Internazionale per il Chimico* (Sansoni, Florence, 1952). There are many general bibliographic guides which contain information of great interest to the Chemical Industry, such as:

Bibliographic Index (Wilson, New York, quarterly).

T. BESTERMAN, *World Bibliography of Bibliographies*, 4th edn. (Societas Bibliographica, Lausanne, 1965–6) (5 vols.).

Internationale Bibliographie der Bibliographien (Klostermann, Frankfurt am Main).

L. N. MALCLES, *Sources du Travail Bibliographique* (Droz, Geneva).

Directories

Both the Institution of Chemical Engineers, London, and the Royal Institute of Chemistry publish lists of members, and the Royal Institute of Chemistry also publishes a *Directory of Independant Consultants in Chemistry and Related Subjects* (Royal Institute of Chemistry, London, irregularly). Some of the most useful general directories for the Chemical Industry are:

Chemical Industry Directory and Who's Who (*Chemical Age*, Benn Bros., London, annually) (Fig. 9).

British Chemicals and their Manufacturers (Association of British Chemical Manufacturers (now Chemical Industries Association) London) (Fig. 10).

Chemical Week Buyer's Guide (McGraw-Hill, New York, annually).

British Chemical Plant (British Chemical Plant Manufacturers Association, London, every 2 years).

Films for the Chemical Industry

Many firms in the Chemical Industry publish catalogues of their films which are of special interest to chemists; these firms include Unilever, ICI, Shell, and British Petroleum. In addition, the Royal Institute of Chemistry, 30 Russell Sq., London, WC 1, publishes *Index of Chemistry Films*.

Conferences, Exhibitions, and Trade Fairs

The Board of Trade Journal (HMSO, London, weekly) gives details of overseas exhibitions and trade fairs. It also includes

Gellner, J. G., B.Sc., F.R.I.C., Dip.F.E. Head of Science Dept., Consett Technical College, Park Rd., Consett, Co. Durham.

Genders, R., M.B.E., D.Met., F.R.I.C., F.I.M. Consulting metallurgist, 40 Grosvenor Gdns., London, S.W.1. General metallurgical consultant with liaison in U.S. & Europe.

Genge, John A. R., M.Sc., Ph.D., F.R.I.C. Senior lecturer in inorganic chemistry, Battersea College of Technology, Battersea Pk. Rd., London, S.W.11.

German, W. L., D.Sc.(Exon.), M.Sc., Ph.D.(Lond.), F.R.I.C., F.I.Ceram. Head, College of Ceramics, North Staffordshire College of Technology, Stoke-on-Trent.

Gerrard, J. S., A.M.I.E.E. Director, Corrosion, Metal & Pipeline Endurance Ltd., 76 Willoughby Lne., Tottenham, London, N.17; director, Corrosion Divn., Mapel (Overseas) Ltd.

Gerrard, William, D.Sc., Ph.D.(Lond.), F.R.I.C. Associate lecturer in Dept. of Chemistry, Northern Polytechnic, Holloway Rd., London, N.7.

Gething, P. A., M.A., Dip.Agric., A.I.C.T.A. Chief agricultural adviser, Potash Ltd., Norfolk Hse., St. James's Sq., London, S.W.1.

Getty, J., B.Agr., Dip.Agr. Managing director & secretary, Poultry Testing & Research (B.E.M.B.) Ltd., Phoenice

Gibson, T., B.Sc., A.R.T.C. Works director, Geigy (U.K.) Ltd., Pigments Divn., Hawkhead Rd., Paisley.

Giddings, W. F., B.Sc.(Eng.), A.C.G.I., D.I.C., F.R.S.A., C.Eng., M.I.E.E. Principal, Acton Technical College, High St., Acton, London, W.3.

Gilbert, Frank Lathe, Ph.D., B.Sc., F.R.I.C. Managing director, Durham Chemical Group Ltd., Birtley, Co. Durham, Durham Chemicals Ltd., Durham Chemicals Investments Ltd., Durham & Bonny Ltd., Durham Chemicals Distributors Ltd., Nuodex Ltd.; director, Durham Raw Materials Ltd., Lindur Metallchemische Produkte G.m.b.H. Cologne. Chmn., North-East Regional Cncl., Brit. Inst. Management. Board member, Washington New Town Development Corp.

Gilbert, Kenneth, A.M.C.T. Sales manager, Berk Spencer Acids Ltd., Theodore St. Just Divn., Radcliffe New Rd., Whitefield, Manchester.

Gilbert, P. T., B.Sc., Ph.D., F.R.I.C., F.I.M., M.I.Mar.E. Chief technical & research executive, Yorkshire Imperial Metals Ltd., Leeds.

Gilbertson, Geoffrey. Division personnel director, I.C.I. Ltd., Agricultural Divn., Billingham, Co. Durham.

Ginns, D. W., M.A.(Cantab.), C.Eng., M.I.Mech.E. Division director, Plastics Divn., I.C.I. Ltd., Welwyn Garden City, Herts. Member, Cncl. Inst. Mech. Eng.

Giusti, R. B. Managing director, T. Giusti & Son Ltd., Belle Isle Wks., 202-222 York Way, King's Cross, London, N.7.

Givens, John Harrison, B.Sc., A.R.I.C. Chairman, Viscose Division, Courtaulds Ltd., Foleshill Rd., Coventry;

Gladstone, M. N., B.Sc. Director & commercial manager, Fisons Pest Control Ltd., Harston, Cambs.; director, Wycon Services Ltd. Chmn., Brit. Weed Control Cncl.

Glanville, Sir William Henry, C.B., C.B.E., D.Sc., Ph.D., M.I.C.E., F.R.S. Consultant, Langthwaite, Kewferry Drive, Northwood, Middx., Formerly director of road research, Road Research Laboratory.

Glaser, Eric Michael, M.C., Ph.D., M.R.C.P., F.I.Biol. Research & development director, Riker Laboratories, Tewin Rd., Welwyn Garden City, Herts.

Glass, Harold Marks, Ph.D., M.Sc., F.R.I.C., F.Inst.Pet., 3 Alexandra Dr., Surbiton, Surrey. Technical director, British Standards Institution. Cncl., Plastics Institute, 1945-47. Cncl., R.I.C., 1962-65.

FIG. 9. *Chemical Industry Directory and Who's Who.* (By permission of Benn Bros. Ltd.)

Foundry feeding compounds .. 29, 125
Foundry flux preparations 120, 125, 198
Foundry grain refiners 125
Foundry pattern plasters 125
Foundry sand bonding materials 9, 25, 29, 31, 39, 88, 125, 127, 199, 205, 228, 313, 345
Froth and foam preventatives .. 6, 87, 136, 172, 196, 225, 227, 252, 313, 345
Fructose 203
Fruit essences 12, 33, 58, 69, 201
Fruit flavours, artificial .. 12, 33, 58, 69, 201
Fuchsin (acid) 142, 164
Fucoidin 203
D-Fucose 203
L-Fucose 203
Fuel additives 102, 111, 136, 172, 202, 204, 233, 268, 345, 354
Fullers' earth, activated *C* 127
P 127
Fullers' earth, natural 29, 127
Fumarase 203
Fumaric acid 57, 164, 233
Fumigants (Agricultural and horticultural) .. 29, 172, 236, 295
Fungicides 6, 15, 29, 34, 35, 58, 59, 75, 78, 102, 115, 123, 155, 172, 202, 204, 206, 224, 225, 233, 236, 252, 268, 279, 295, 313, 316, 352, 354, 366
Fur dressings 136, 196
Furfuraldazine 203
Furfuraldehyde (specially purified) 41, 134, 164
Furfurylamine 295
α-Furfurylmercaptan
See α-Furylmethanethiol
Furil 41, 134, 164
α-Furildioxime 134, 164
α-Furoic acid 203, 207
Furoin 41, 134, 164
2-Furoyl chloride 73, 207
α-Furylmethanethiol 203, 207
Fusion mixture 41, 134, 156, 164
Fustic extract 42, 365

G acid
See 2-Naphthol-6:8-disulphonic acid
G salt
See Sodium 2-naphthol-6:8-disulphonate
Gadolinium, metal and compounds 179, 338
Galactose 203
Galacturonic acid 203
Gallamine blue 142
Gallamine triethiodide 224
Gallein *P* 142, 164
Gallic acid *C* 42, 180
P 42, 180, 248
Gallium, metal and compounds .. 179
Gallocyanine 41, 134, 142
Gamma acid *C* 77
Gas chromatography, reagents for 41, 203, 224, 227
Gas purifying material 155, 225, 317, 321, 322
Gelatine *C* 45
P 45
Gelling agents 9, 29, 33, 88, 136, 155, 365
Gentian violet 41, 142
Gentisic acid 203
Geraniol 12, 33, 58, 69, 174
Geranyl acetate 33, 58, 69, 174
Geranyl butyrate 58
Geranyl *iso*butyrate 58
Geranyl formate 33, 58
Geranyl propionate 58
Geranyl *iso*valerate 58
Germanium, zone-refined 179
Germanium dioxide 179
Germanium tetrachloride 179
Germicides 29, 34, 83, 114, 120, 136, 172, 231, 233, 251, 259, 277
Gibberellic acid 172
Giemsa's stain 41, 142, 164
Gingerin 12, 58, 217, 290
Girard's reagent P 41
Girard's reagent T 41
Gland extracts 34
Glauber's salt
See Sodium sulphate
Gliadin 41
Globin hydrochloride 10
Globin insulin 10, 34, 41, 56
Gluconic acid 272
1:5-Gluconolactone 272
D-Glucosamine hydrochloride .. 203, 217
D-Glucose (1-dipotassium phosphate) .. 203
D-Glucose (1-disodium phosphate) .. 203
Glucose penta-acetate 41, 203
β-Glucosidase 203
β-Glucuronidase 203
Glucuronolactone 203
Glue, marine 162
Glue preservatives 38, 228, 233
Glues 31, 45, 344
D-Glutamic acid 203

C = Commercial grades.
P = Fine chemical, pharmaceutical, pure, analytical and similar grades.

See also "Proprietary and Trade Names," page 152.

FIG. 10. *British Chemicals and their Manufacturers.*
(By permission of the Chemical Industries Association Ltd.)

information for exporters such as tariffs and customs and import regulations in overseas countries.

The following publication gives advanced details of conferences of interest to chemists and the Chemical Industry: *Forthcoming International Scientific and Technical Conferences* (Department of Education and Science, London), issued each January and July with additions each April and October.

CHAPTER 5

Organizations

In this chapter we have selected a number of typical guides to information and organizations in or closely related to the Chemical Industry. These are merely examples and the list is not intended to be exhaustive. Most of those mentioned have local branches which hold regular meetings and so enable their members to meet each other, to keep abreast of new developments, and to discuss informally problems of common interest. In general, we only refer to the organizations for the specialized industries in Chapter 6.

Professional Organizations

Chemical Industry Directory and Who's Who (*Chemical Age*, Benn Bros., London, annually) (Fig. 9) is quite a comprehensive general directory which gives a good coverage of the principal chemical and allied organizations, but unfortunately this section of it has no subject index. Another good general guide to the professional societies is *Professional and Learned Societies of Great Britain* (Allen & Unwin, London, annually), which is edited by the British Council: also P. Millard, *Trade Associations and Professional Bodies of the United Kingdom*, 3rd edn. (Pergamon, Oxford, 1966).

The professional organization for chemists in Great Britain is the Royal Institute of Chemistry, 30 Russell Sq., London, WC 1, which offers various grades of membership and postgraduate diplomas. In its leaflet *Qualifications in Chemistry* it explains many qualifications and courses in chemistry. It also publishes the *Journal*, *A Directory of Independent Consultants*, *A Register of*

Corporate Members, and several booklets about careers, films, and teaching.

The Society of Chemical Industry, 14 Belgrave Sq., London, W 1 is concerned with the advancement of applied chemistry. It publishes information and holds meetings in Britain and many other countries.

For chemical engineers the professional body is the Institution of Chemical Engineers, 16 Belgrave Sq., London, SW 1, which publishes various booklets on education and training, scholarships and careers, as well as *The Chemical Engineer* and *Transactions*.

In biochemistry, the Biochemical Society, 20 Park Crescent, London, W 1, is the professional body. It publishes booklets on teaching, training, and careers, etc., in addition to *The Biochemical Journal*.

In the Chemical Industry there are also represented many other professions, such as mechanical and electrical engineers, whose respective professional bodies are: the Institution of Mechanical Engineers, 1 Birdcage Walk, London, SW 1, and the Institution of Electrical Engineers, Savoy Place, London, WC 2. Sometimes firms make use of the services of a consultant chemist or engineer and, although all the professional bodies mentioned in this section will provide suitable names, there are two professional associations which are worth mentioning: the Association of Consulting Scientists, Park House, Hawthorne Rd., Bromley, Kent, and the Association of Consulting Engineers, Abbey House, 2 Victoria St., London, SW 1.

The Chemical Council is not, strictly speaking, a professional body itself. It was set up in 1935 by the Chemical Society, the Royal Institute of Chemistry, and the Society of Chemical Industry with representatives from the Association of British Chemical Manufacturers (now known as the Chemical Industries Association), the Faraday Society, the Society for Analytical Chemistry, and the Biochemical Society. Its main function is to act as trustees for the contributions mainly from the Chemical Industry. This money is used to help its constituent societies to pay for their publishing costs and in various other ways. Therefore the

Chemical Council is included here because it has close links with many of the best-known organizations in the British Chemical Industry, including professional organizations.

The Chemical Society, Burlington House, London, W 1, is the oldest national chemical society in the world. It has several publications, including *Proceedings*, the *Journal*, and *Annual Reports on the Progress of Chemistry*, to mention only a few. It also translates and publishes in English the following Russian publications:

Journal of Organic Chemistry.
Journal of Physical Chemistry.
Chemical Reviews.

There are many specialized professional organizations and those that follow are a few of the better known ones. The Faraday Society, 6 Grays Inn Sq., London, WC 1, is especially devoted to physical chemistry, colloid chemistry, and related subjects.

In most chemical plants heat energy is utilized and in this field there is the Institute of Fuel, 18 Devonshire St., London, W 1, which publishes monthly *Journal of the Institute of Fuel*, *Fuel Abstracts and Current Titles*, and other publications. There is also the Society for Analytical Chemistry, 14 Belgrave Sq., London, SW 1.

The Oil and Colour Chemists' Association, Wax Chandler Hall, Gresham St., London, EC 2, is concerned with the technologies of paint, ink, drying oils, soaps, linoleum, treated fabrics and their plant, apparatus, and raw materials. The Pharmaceutical Society of Great Britain, 17 Bloomsbury Sq., London, WC 1, is of particular interest to chemical firms which manufacture pharmaceuticals.

The Plastics Institute, 6 Mandeville Place, London, W 1, and the Institution of the Rubber Industry, Kensington Palace Gardens, London, W 8, work closely together to serve their members, whose interests often overlap. As a result the two bodies have formed a joint examinations board and it is likely that they will merge completely shortly.

Trade Organizations

One of the most useful general guides to trade organizations is P. Millard, *Trade Associations and Professional Bodies of the United Kingdom*, 3rd edn. (Pergamon, Oxford, 1966). Another very useful source of information, which is not generally available, being mainly intended for use by government offices, is *Trade Associations and Export Groups* (Board of Trade, Statistics and Market Intelligence Library, London, 1966), to whom inquiries may be addressed regarding both trade associations and export groups.

The Chemical Industries Association, Alembic House, 93 Albert Embankment, London, SE 1 (Tel. Reliance 3001), is the foremost organization of the chemical manufacturing, trading, and allied industries. It was formed in 1966 by the amalgamation and reorganization of the Association of British Chemical Manufacturers and the Association of Chemical and Allied Employers. As the ABCM, it published an excellent directory, *British Chemicals and their Manufacturers* (Fig. 10), and it is expected that this and similar publications will continue.

The CIA represents the general interests of the chemical and allied industries and deals with technical and commercial problems for them including fuel efficiency, instrumentation, marking of containers for hazardous chemicals, packaging, trade effluents, patents and trade marks, transport, standardization, productivity, work-study, and work-safety.

Since the reorganization, the CIA has reassessed the status and potential of the Chemical Industry and established itself as a consultative body with Government and with chemical industry "neddies". It has already drawn attention to the very inadequate statistical information on which decisions and recommendations have to be based and has made proposals for better arrangements. The other activities which the CIA has highlighted in its first survey of the chemical scene include the vexed question of definition of the industry; manpower-needs, unskilled, skilled, and graduate; co-operation with the Society of Chemical Industry to

make the industry better understood generally and more particularly in schools, universities, and colleges; and in addition to all these long-term commitments, the question of safety in working within the industry is being studied.

There are numerous smaller trade associations which exist mainly as a meeting place for competing firms to discuss matters of common interest such as representations to the Government, employment policies, etc. Details of these organizations can be obtained from the Board of Trade, Horse Guards Ave., London, SW 1 (Tel. Trafalgar 8855).

Among the better-known trade organizations is the Association of British Pharmaceutical Industry, Mercury House, Knightsbridge, London, SW 7 (Tel. Kensington 8201). Manufacturing chemists are often concerned with the production of patent medicines and repacking for retail sale materials such as castor oil; hence the Association of Manufacturing Chemists Ltd., 41 Holborn Viaduct, London, EC 1, exists particularly to protect its members with status reports and credit control information.

There are many firms in the chemical trade which only import or merchant chemicals, and such firms are represented by the British Chemical and Dyestuffs Traders Association, 12B Westminster Palace Gardens, Victoria St., London, SW 1.

For chemical plant manufacturers, the trade association is the British Chemical Plant Manufacturers Association, 14 Suffolk St., London, SW 1, which produces an excellent biennial directory, *British Chemical Plant*. Similarly, the glass industry has its trade association: the Glass Manufacturers Federation, 19 Portland Place, London, W 1.

Many countries have organizations set up to issue standard specifications to which equipment, materials, and codes of practice must comply in the interest of both producer and consumer. In Britain the body concerned is the British Standards Institution, 2 Park St., London, W 1 (Tel. Mayfair 9000). This has a reference library containing all British standards, international standards recommendations, and standards issued by over fifty countries of which the titles are translated and indexed in English.

BSI publications include *BSI News* (monthly), *BSI Year Book* (annually), and the *BSI Annual Report* (annually).

There are a number of smaller and/or more specialized trade associations which are sometimes concerned mainly with the purchasing of raw materials, e.g. the National Sulphuric Acid Association, 33 Regent St., London, SW 1, and the United Kingdom Glycerine Producers Association, 5 Bridewell Place, London, EC 4 (Tel. Fleet Street 5949). Others include the Whiting Federation, 30 Church St., Welwyn, Herts., and the British Plastics Federation, 47 Piccadilly, London, W 1 (Tel. Regent 2041). Some of these bodies collect and publish statistics relating to their respective industries, and we have made use of them elsewhere in this volume, others arrange talks or give non-technical information to, for example, the Trade Press.

Employers' Organizations

The standard reference work on employers' organizations is The Department of Employment and Productivity, *Directory of Employers' Associations, Trade Unions and Joint Organizations, etc.* (HMSO, London, 1960). Amendments are issued once or twice a year in order to keep it up to date.

The functions which used to be spread over several bodies are now largely vested in CIA, which has been more fully described earlier in this chapter.

Employees' Organizations

The following is a good guide to the trade unions in the Chemical Industry in the United Kingdom: The Department of Employment and Productivity, *Directory of Employers' Associations, Trade Unions and Joint Organizations, etc.* (HMSO, London, 1960), for which amendments are issued at frequent intervals.

On a more professional basis, the British Association of Chemists, Hinchley House, 14 Harley St., London, W 1, includes in its membership many qualified chemists.

The following are also active in endeavouring to secure for their members the best in remuneration, working conditions, hours of work, etc.

1. The Association of Scientific Workers, 15 Half Moon St., London, W 1 (Tel. Grosvenor 4761).
2. Chemical Workers Union (incorporating the National Union of Drug and Chemical Workers and National Association of Chemists' Assistants, and affiliated to the National Federation of Professional Workers in respect of its professional, technical, and administrative workers), Dalton House, 155 Kensington Park Rd., London, SE 11 (Tel. Reliance 3938).
3. Mid-Cheshire Salt and Chemical Industries Allied Workers Union, the Central Palace Drive, Northwich, Cheshire (Tel. Northwich 3034).
4. Federation of Trade Unions of Salt Workers, Alkali Workers, Mechanics, and General Labourers, the Brunner Guildhall, High St., Winsford, Cheshire (Tel. Winsford 2379).

Joint Negotiating Machinery

There are no wages councils as such for the British Chemical Industry. However, there are several joint councils on which employers and their non-staff grades of employee are represented. These councils meet in order to avoid disagreements and although the higher management of the firms are not bound to act on their recommendations they do often find it prudent to take them into consideration. Conversely, through them employers can keep employees aware of company developments and how employees will be affected, in order to prevent the unrest which pessimistic rumours can cause.

The principal joint negotiating bodies of the Chemical Industry are:

Chemical and Allied Industries Joint Industrial Council
Chemical Joint Industrial Council

Drug and Fine Chemical Joint Conference
Fertilizers Joint Industrial Council
Plastics Group Joint Industrial Council
National Joint Council for the Paint, Varnish, and Lacquer Industry
Gelatine and Glue Joint Industrial Council
Soap, Candle, and Edible Fats Trades Joint Industrial Council.

Each of these bodies has an employers' secretary and a workpeople's secretary. Full details are given in Ministry of Labour, *Directory of Employers' Associations, Trade Unions and Joint Organizations, etc.*, and its subsequent amendments (HMSO, London, 1960).

Other Organizations

In any industry there are represented many occupations which may be common to other industries; for example accountancy, marketing, and office management. These are, in many cases, well served by professional organizations which organize examinations and award various grades of membership, some of which carry considerable status and are the generally accepted qualifications in their field. For example, in cost accountancy, the Institute of Cost and Works Accountants, 63 Portland Place, London, W 1, is concerned with all aspects of this profession. Similarly, the Institute of Chartered Accountants in England and Wales, Moorgate Place, London, EC 2, is the largest body of its kind in the United Kingdom.

With the growth of interest in the science of management, firms are increasingly employing specialists most of whom have professional organizations such as the Institute of Personnel Management or the British Institute of Management, both of 80 Fetter Lane, London, EC 4 (Tel. Holborn 3456), or the Institute of Works Managers, 196 Shaftesbury Ave., London, WC 2 (Temple Bar 8324).

Firms which undertake a considerable volume of scientific research usually employ their own patent officers whose professional body is the Chartered Institute of Patent Agents, Staple Inn Buildings, London, WC 1. Likewise, the larger firms have librarians, translators, and information scientists who frequently work closely together. Their respective organizations are:

Library Association, Chaucer House, Malet Place, London, WC 1; Aslib (formerly the Association of Special Libraries and Information Bureaux), 3 Belgrave Sq., London, SW 1; the Institute of Linguists, 3 Craven Hill, London, W 2; and the Institute of Information Scientists, 5–7 Russia Row, London, EC 2.

Again in the larger firms, the sales departments are in many cases divided into home and export sales; the respective professional bodies being the Institute of Marketing and Sales Management, Marketing House, Richdell Place, London, WC 1, and the Institute of Export, 14 Hallam St., London, W 1.

With the growing use of radio-isotopes in, for example, detecting leaks in buried pipelines, etc., there are two organizations which are of special value. For general advice and guidance regarding the feasibility of using radio-isotopes for a particular application the following should be contacted: the Industrial Liaison Officer, UKAEA Isotopes Division, Wantage Research Laboratories, Wantage, Berks. For supplies, prices, etc., of radioactive materials the following should be contacted: the Radiochemical Centre, Amersham, Bucks.

Government, Armed Forces, and Nationalized Industries' Organizations

The Economic Development Council for the Chemical Industry was set up in 1964 and reconstituted in 1966. It consists of nine members from the industry, four representing trade unions, three the Government, and one independent. Terms of reference are:

1. To examine the economic performance, prospects, and plans of the industry and to assess from time to time the industry's progress in relation to the national growth objectives, and to

provide information and forecasts to the National Council (NEDC) on these matters.

2. To consider ways and means of improving the industry's economic performance, competitive power, and efficiency, and formulate reports and recommendations in these matters as appropriate.

The Committee has already examined the steep rise in chemical imports between 1962 and 1964; a detailed questionnaire on exports has been prepared, answered, and considered; on productivity a team has visited the United States to compare the manning of chemical plants in the two countries. The definition of the Chemical Industry has been widened to facilitate these investigations, but this has raised problems in comparing statistics and the Board of Trade has set up a working party including EDC representatives to study the question of statistics in the Chemical Industry; a sub-committee already studies the effects of structure on efficiency with a view to advising the Industrial Reorganization Corporation on "coalescence" if and where it is thought to be helpful. The Committee also supports a scheme for interfirm comparison within the Chemical Industry.

This represents the closest collaboration taking place between the industry and the Government and given wise direction and support it must yield good results in the long term. Its publications will be an up-to-date running commentary on the industry from time to time. These reports can be obtained from the NEDC Office, Millbank Tower, 21–41 Millbank, London, SW 1.

At the time of writing (1967) the Chemical Industry Training Board is about to be formed by the Ministry of Labour.

Various other government ministries have different responsibilities in relation to the Chemical Industry and amongst the most important are:

HM Factory Inspectorate, Ministry of Labour (working conditions and safety).

Alkali Inspectorate, Ministry of Housing and Local Government (effluents, etc.).

Warren Spring Laboratory, Ministry of Technology (chemical processes, air pollution, mineral processing, etc.).

Laboratory of the Government Chemist, Ministry of Technology (public health, advice to other government departments, etc.).

Chemical Standards Division, National Physical Laboratory (heat capacity, properties and preparation of pure chemical compounds, etc.).

There are numerous government committees and panels concerned with chemicals, additives, and drugs, and these are listed in Department of Education and Science, *Chemicals, Additives and Drugs* (HMSO, London, 1965). This is a short working guide to the structure of these government committees and panels. It is particularly useful to the press as it outlines the structure and work of the twenty-one committees and include details of the press inquiry point in each case.

There are many government organizations concerned with chemistry, and many of these are listed in British Council, *Scientific and Learned Societies of Great Britain* (Allen & Unwin, London, annually). For example:

Agricultural Research Council, Radiobiological Laboratory, Letcombe Regis, Wantage, Berks.

Admiralty Materials Laboratory, Holton Heath, near Poole, Dorset.

Medical Research Council, Air Pollution Research Unit, St. Bartholomew's Hospital Medical College, Charterhouse Sq., London, EC 1.

In *Chemical Industry Directory and Who's Who* (*Chemical Age*, Benn Bros, London, annually), details, national and regional, of government departments and ministries and nationalized industries are given (Fig. 9). For example, under British Railways, Chemical Research Division, both details are shown of headquarters and various regional laboratories working on protective coatings, building materials, and corrosion.

Foreign Organizations

Probably the quickest way to find out what organizations exist in other countries is to contact the nearest consul or the embassy of the country concerned. One of the most convenient guides to this information is *Whitaker's Almanack* (Whitaker, London, annually); see the section headed "Foreign Countries".

In the United States the following are all good sources of information in their own fields:

American Association for the Advancement of Science, 1515 Massachusetts Ave., Washington 5, DC, USA.

American Association of Textile Chemists and Colorists, Box 28, Lowell, Mass., USA.

American Institute of Chemical Engineers, 25 West 45th St., New York, NY, USA.

In the USSR the following are all conveniently centralized sources of information about their respective fields:

1. Ministry of Chemical Engineering, Moscow I–110, Bezbozhnyi Pereulok 25 (Head of Foreign Relations Department: G. O. Terzyan).
2. Ministry of the Chemical Industry, Moscow, Ulitsa Kirova 20 (Head of Foreign Relations Department: V. N. Fedorov).
3. Ministry of the Petroleum Refining and Gas Industry, Moscow, Ulitsa Gilerovskovo (Head of Foreign Relations Department: I. A. Pushkin).
4. All-Union Institute of Scientific and Technical Information, Moscow D–219, Baltiiskaya Ulitsa d.14 (Director: A. I. Mikhailov).
5. The Chemical Engineering Scientific Research and Design Institute, Moscow A–15, Bol'shaya Novo-Dmitrovskaya Ulitsa 14 (Head of Foreign Relations Department: V. V. Vayalkin).
6. The Moscow Institute of Chemical Engineering (MIKhM), Moscow, Ulitsa Karla Marksa 21–4 (Deputy Director: D. M. Kokorev).

CHAPTER 6

The Specialized Industries

IT WILL be recalled that in the grouping classification of the Chemical Industry (p. 18), apart from the inorganic chemicals and organic chemicals there is a series of specialized product groups ranging from dyestuffs, explosives, and pharmaceuticals through a wide range to pest-control products, plastics, and plasticizers. In the CIA classification these are alloted the key numbers S1–S33, and we adhere to these numbers in this chapter.

Each of these specialized groups is an industry in itself, and although based on the fundamental principles of chemistry and physics they incorporate specialized processes and plant specifications and tests, and require a wealth of technical and scientific knowledge, usually gained by experience within that particular industry.

Nevertheless, some have acquired such importance in the economy that they have become the subjects of special courses in universities and colleges of technology in various parts of the country, as, for example, textiles and dyeing in Leeds and Manchester; agriculture and horticulture in Bristol, Nottingham, and Reading; leather in Leeds; metallurgy in Sheffield; and paper science in Manchester, to name only a few.

These technological courses offer facilities to students who have already made up their minds to seek a post in one of the specialized chemical industries as distinct from the academic courses which teach a science rather than its application. In all the technological courses the early years are spent in gaining a knowledge of the fundamentals of the appropriate science or sciences, and the later

years in studying the techniques and the theoretical basis of the industry itself.

As each group possesses its own characteristics as to structure, training, and so on, a section is devoted to each in what follows, giving the main features and the organized bodies, journals, books, and other relevant information.

S1 Adhesives and Gelatines

The Adhesives Industry, originally based on the natural raw materials, glues, gelatines, casein, and rubber latex, branched out in great style in the 1940's with the advent of the epoxy-resins, which immediately showed great promise as structural adhesives. Now many resin types can be used to produce "tailor-made" adhesives to meet exacting specifications for specific uses.

Books

Adhesives Directory 1966, published by A. S. O'Connor & Co. Ltd., 30 Paradise Rd., Richmond, Surrey—the first of its kind, giving information on adhesives, tapes, plant and equipment, raw materials, trade names, who's who in adhesives, and glossary of terms. The intention is to publish each year.

R. Houwink and G. Salomon (Eds.), *Adhesion and Adhesives* (Elsevier, Holland, 1965).

W. H. Guttmann, *Concise Guide to Structural Adhesives* (Reinhold, New York, 1961).

J. Delmonte, *The Technology of Adhesives* (Hafner, New York, 1965).

D. D. Eley, *Adhesion* (Oxford University Press, 1961), produced for the Advisory Council on Scientific Research and Technological development).

I. Skeist (Ed.), *Handbook of Adhesives* (Reinhold, New York, 1962).

For those who want a very brief introduction:

J. HURD, *Adhesives Guide*, published by the British Scientific Instrument Research Association, Chislehurst, Kent, 1959.

R. S. R. PARKER and P. TAYLOR, *Adhesion and Adhesives*—the most recent (Pergamon, Oxford, 1966).

Journal

Resin News (monthly), broadsheet published by A. S. O'Connor & Co. Ltd., 30 Paradise Rd., Richmond, Surrey.

Research Association

The Gelatine and Glue Research Association, Sardinia House, 52 Lincolns Inn Fields, London, WC 2. They publish quarterly abstracts of current literature and a bulletin, available to members.

Trade Associations

Adhesive Manufacturers' Association, 6 Holborn Viaduct, London, EC 1.

British Rubber and Resin Adhesives Manufacturers Association, c/o A. C. Palmer & Co., Court Chambers, Firar Lane, Leicester.

Casein Glue Manufacturers Association, c/o Leicester, Lovell & Co. Ltd., North Baddesley, Southampton.

Federation of Glue and Gelatin Manufacturers, 52 Lincoln's Inn Fields, London, WC 2.

S2 Detergents and Other Surface-active Agents

The Detergent Industry is best known to the public through the advertising campaigns like "whiter than white". The traditional methods of cleansing with soaps must have persisted unbroken for many centuries, and it is only in very recent times that certain organic surface-active agents were shown to have advantages over

soap in specific instances. The detergents used for domestic purposes (and in industry) are mixtures containing a comparatively small quantity of a surface-active ingredient mixed with "inorganics" such as silicates, phosphates, sulphates, perborates, and now usually an "optical whitening" agent, which is the material which promotes the "whiter than white" effect. The industry therefore includes not only the makers of the detergents but also those chemical manufacturers making the various surface-active ingredients and the chief compounding materials.

Books

MOILLIET, COLLIE, and BLACK, *Surface Activity*, 2nd edn. (Spon, London, 1961).

K. DURHAM (Ed.), *Surface Activity and Detergency* (Macmillan, London, 1961).

J. W. MCCUTCHEON, *Synthetic Detergents* (MacNair-Dorland, New York, 1950).

The above deal with the active materials and the theory of their application. The following considers detergents from the point of view of the industry in which they are applied—laundry, dry-cleaning, textiles, food and beverages, dairy, dish-washing, and metals.

W. W. NIVEN (Ed.), *Industrial Detergency* (Reinhold, New York, 1955).

Journals

Soap, Perfumery and Cosmetics (monthly), United Trade Press, 9 Gough Sq., Fleet St., London, EC 4. Accredited organ of the British Perfumery, Cosmetic and Detergent Industries.

Cleaning and Maintenance (monthly), Wheatland Jnls., Stamford House, 65–6 Turnmill St., London, EC 1. It is the official journal of the British Institute of Cleaning Science and has

papers on all aspects of cleaning and maintenance—laundries, carpets, floors, buildings, paintwork, windows, etc.

Soap and Chemical Specialities, MacNair-Dorland, New York.

Research Associations

None is entirely devoted to this subject, but there is a National Committee, recently formed to make liaison with the Comité International de la Detergence, to standardize terms and procedures for surface-active agents. They organize international congresses on the subject, the fourth being held in 1964.

British National Committee on Surface-active Agents, Alembic House, 93 Albert Embankment, London, SE 1.

Trade Associations

Soap Makers Association, 6 Holborn Viaduct, London, EC 1.

Soap, Candle and Edible Fats Trades Employers Federation, 2 Kingscote St., London, EC 4.

Society of British Soap Makers, c/o Carter, Son & White, 16 Northumberland Ave., London, WC 2.

S3 Disinfectants

The terms "antiseptic" and "disinfectant" are often used loosely as equivalent, and it is true that both refer to substances which prevent or delay putrefaction. An antiseptic, however, is usually applied for this purpose to living tissue, and therefore its toxic properties and side-effects are important, whereas a disinfectant is used for the cleansing of contaminated articles, vessels, implements, etc., and for prior treatment of such articles to prevent contamination. The toxic properties of a disinfectant are therefore less important, and many chemicals can be used as disinfectants which cannot be used as antiseptics to be applied to living tissues. However, manufacturers frequently make both

groups, although antiseptics would come under the conditions of the pharmaceutical industry.

Books

The most authoritative and complete book on the subject is WILSON and MILES, *Topley and Wilson's Principles of Bacteriology and Immunity* (Arnold, London, 1955).

A good first primer is W. E. FINCH, *Disinfectants: their values and uses* (Chapman & Hall, London, 1958).

Slightly more medical is S. D. RUBBO and J. GARDNER, *Sterilization and Disinfection* (Lloyd-Lake (Medical Books) Ltd., London, 1965).

A fuller treatise is G. SYKES, *Disinfection and Sterilisation* (Spon, London, 1958).

From the US industry is L. SCHWARZ, *Sanitary Chemicals* (MacNair-Dorland, New York, 1953), and

E. C. MCCULLOCH, *Disinfection and Sterilization*, 2nd edn. (Lea & Fabiger, Philadelphia, 1945).

Trade Association

British Disinfectant Manufacturers' Association, Alembic House, 93 Albert Embankment, London, SE 1.

Journal

Cleaning and Maintenance—see page 94.

S4 Dyestuffs

This group refers to the manufacture of dyestuffs and intermediates, not to the actual dyers who are classified in the textile industries. Here, however, we have included books and journals relating to the application of dyes as well as their manufacture, as everyone in dye-manufacture will want to know something of their use.

Books

The most important books on the subject are still the up-to-date editions of the "old masters".

CAIN and THORPE, *Synthetic Dyestuffs* (Griffin & Co, London, 1946).

FIERZ-DAVID and BLANGEY, *Fundamental Processes of Dye Chemistry* (Interscience, New York, 1949).

H. A. LUBS, *Synthetic Dyes and Pigments* (Reinhold, New York, 1955).

A shorter introduction is G. H. FRANK, *The Manufacture of Intermediates and Dyes* (Constable, London, 1950).

For the application of dyes to textiles, the authentic work is still KNECHT, RAWSON, and LOEWENTHAL, *The Manual of Dyeing*, 9th edn. (Griffin, London, 1933).

The most up-to-date dyeing manual is WILCOCK and ASHWORTH, *Whitaker's Dyeing with Coal Tar Dyestuffs*, 6th edn. (Baillière, Tindall & Cox, London, 1964). See also E. R. TROTMAN, *Dyeing and Chemical Technology of Textile Fibres* (Griffin, London, 1963).

For a better scientific understanding of the process of dyeing: VICKERSTAFF, *The Physical Chemistry of Dyeing* (Oliver & Boyd, London, 1954).

The reference book to all commercial dyes with history, chemistry, application, and tests is F. M. ROWE (Ed.), *The Colour Index* (Fig. 11) sponsored by the Society of Dyers and Colourists, Bradford. Often referred to as "The Dyers' Bible".

Journals

Journal of the Society of Dyers and Colourists (monthly), Dean House, 19 Piccadilly, Bradford.

Summary of Current Literature on Textiles and Dyeing. Shirley Institute, Didsbury, Manchester, 20.

C.I. Basic Red

Page
1629 **C.I. BASIC RED 1**

add **Calcozine Rhodamine 6GX** ... **CCC**
Mitsui Rhodamine 6GCP ... **MDW**
Rhodamine 6G
Rhodamine 6G extra ... **BASF**
Rhodamine 6GBN ... **ICI**
Rhodamine 6GCP ... **BASF**
Rhodamine 6GDN ... **AAP**
BUC
Rhodamine 6GDN extra **BASF**

delete **Aizen Rhodamine 6GH** ... **HCC**
Diabasic Rhodamine 6GCP **MCI**
Mitsui Rhodamine 6GCP **MCW**
Rhodamine 6G Extra base **CAC**
Ciba

C.I. BASIC RED 2

add **Safranine A** ... ... **BUC**
Safranine TS ... ... **FH**
Safranine Y ... ... **AAP**

delete **Aizen Safranine TH** ... **HCC**
Safranine T ... ... **W**

1630 **C.I. BASIC RED 3**

delete **Rhodamine 3G** ... ... **LBH**

C.I. BASIC RED 4

add **Rhodamine 3G** .. ... **LBH**

Page
1631 **C.I. BASIC RED 8**

delete **Rhodamine G** ... ... **CAC**
Ciba
Rhodamine J ... ... **Fran**

C.I. BASIC RED 9

add **Calcozine Magenta N** ... **CCC**
Fuchsine DR-001 ... **SUC**
Fuchsine Y ... ... **NAC**

C.I. BASIC RED 10

delete **Brilliant Basic Red B** ... **FH**

C.I. BASIC RED 11

delete **Rhodamine S** ... ... **BASF**
Fran

1632 **C.I. BASIC RED 12**

add **Astra Phloxine G extra** ... **FBy**
Tokyo Aniline Astraphloxine FF **KKK**

C.I. BASIC RED 13

add **Aizen Cathilon Pink FG** ... **HCC**
Nabor Brilliant Pink 2B ... **NAC**

C.I. BASIC RED 14

add **Deorlene Brilliant Red 4G** **CAC**
CIBA
Genacryl Pink 3G ... **G**
Nabor Brilliant Red 4G ... **NAC**

Methine

C.I. Basic Red 15

APPLICATION DYEING

Polyacrylonitrile From a mildly acid bath, at atmospheric pressure at the boil or under pressure at 110° C. [illegible] a retarding agent is added to promote levelling

Effect threads Cotton slightly stained, wool unstained

PRINTING

Polyacrylonitrile, Acetate and Nylon By direct processes

HUE **Bright Bluish Red**

ARTIFICIAL LIGHT slightly yellower

Genacryl Brilliant Red B ... ... **G**
Sevron Brilliant Red B ... ... **DuP**

FASTNESS PROPERTIES etc

	Polyacrylonitrile A
ACID (30% Acetic)	5
HOT PRESSING	5
LIGHT ½ Normal	4–5
Normal	5
2 × Normal	5
MILLING	5
PERSPIRATION Alkaline	5
VOLATILITY (Dry steam)	5
SUBLIMATION (Dry steam)	5
WATER SPOTTING	5
WASHING (IIIA) Alteration	4–5
Staining	5

SOLUBILITY Soluble in hot slightly acid solution

TEXTILE USAGE For dyeing and printing polyacrylonitrile fibres

Reactions in Substance H_2SO_4 conc.—pale greenish yellow; on dilution—paler

---

Triarylmethane

C.I. Basic Red 16

APPLICATION DYEING

Polyacrylonitrile From a mildly acid bath, at atmospheric pressure at the boil or under pressure at 110° C.

PRINTING

Polyacrylonitrile By direct processes

HUE **Dull Bordeaux**

ARTIFICIAL LIGHT yellower and brighter

Sevron Bordeaux G ... ... **DuP**

FASTNESS PROPERTIES etc

	Polyacrylonitrile A
LIGHT (2%)	5–6 (weaker) (Fade-Ometer)
MILLING	5
PERSPIRATION Alkaline	5
VOLATILITY (Dry steam)	5
WASHING (IIIA)	4–5 (yellower)

SOLUBILITY Soluble in hot, slightly acid solution

TEXTILE USAGE For dyeing and printing polyacrylonitrile fibres; suitable for different types of modified acrylic fibres

Reactions in Substance H_2SO_4 conc.—dull yellow

FIG. 11. *The Colour Index*
(By permission of the Society of Dyers and Colourists.)

International Dyer (monthly), deals with dyeing, textile printing, bleaching, finishing, and reports all that occurs in these industries: Harlequin Press, Grand Buildings, Trafalgar Sq., London, WC 2.

American Dyestuff Reporter (fortnightly), official journal of the American Association of Textile Chemists and Colorists, deals with all problems of textile wet processing, and contains abstracts, technical articles, and all Association news.

Research Associations

Cotton, Silk, and Man-made Fibres Research Association, Shirley Institute, Didsbury, Manchester, 20.

Wool Industries' Research Association, Torridon, Headingly Lane, Leeds, 6.

Dyers' and Cleaners Research Association, Forrest House Laboratories, Knaresborough Rd., Harrogate.

Trade Association

British Chemical and Dyestuff Traders' Association, 126 Westminster Palace Gardens, Victoria St., London, SW 1.

Technical Societies

Society of Dyers and Colourists, Dean House, 19 Piccadilly, Bradford.

Textile Institute, 10 Blackfriars St., Manchester, 3.

S5 Essential Oils, Isolates, Perfumes, and Synthetic Aromatics

This is the branch of the Chemical Industry which provides perfumes and flavours. These were originally mainly natural products, but the processes of concentration, isolation, and purification entailed great skill and experience. Many still are isolated from natural products, but a good number are now synthesized.

Books

E. GUENTHER, *The Essential Oils*, 7 vols. (Van Nostrand, New York, 1948).

P. Z. BEDONKIAN, *Perfumery Synthetics and Isolates* (Van Nostrand, New York, 1951).

T. F. WEST, STRAUSZ, and BARTON, *Synthetic Perfumes* (Arnold, London, 1949).

W. A. POUCHER, *Perfumes, Cosmetics and Soaps* (Vol. I. Dictionary of Raw Materials and Nomenclature, Vol. II. Manufacture, Vol. III. Modern Cosmetics, 6th edn. (Chapman & Hall, London, 1959).

R. W. MONCRIEFF, *The Chemistry of Perfumery Materials* (United Trade Press, London, 1949).

Especially for Students:

P. JELLINEK (trans. A. J. KRAJKEMAN) *The Practice of Modern Perfumery* (Leonard Hill, London, 1954).

S. MAURER (Ed.), *Perfumes and their Production* (United Trade Press, London, 1958).

Journals

Perfumery and Essential Oil Record: for industrial users of aromatic, cosmetic, and flavour materials (monthly), Hexagon Publishing Co. Ltd., 84–6 Grays Inn Rd., London, WC 1.

American Perfumer and Cosmetics (monthly), 1031 South Blvd., Oak Park, Ill.

Soap, Perfumery and Cosmetics (monthly), United Trade Press, 9 Gough Sq., Fleet St., London, EC 4. Accredited organ of the British Perfumery, Cosmetic, and Detergent Industries having international status.

Trade Associations

British Essence Manufacturers' Association, 69 Cannon St., London, EC 4.

Essence Export Group, 69 Cannon St., London, EC 4.

Flavouring Compound Manufacturers' Association of Great Britain, 69 Cannon St., London, EC 4.

British Aromatic Compound Manufacturers' Association, 69 Cannon St., London, EC 4.

S6 Explosives

This industry is in comparatively few hands and much of the research and development work is necessarily carried out in government research centres.

Books

A monumental work has just recently been published, T. URBANSKI, *The Chemistry and Technology of Explosives*, 4th edn. (Pergamon, Oxford, and P.W.N., Warsaw, 1964).

A short introduction to the subject is J. READ, *Explosives* (Penguin, 1942).

The most recent books on this subject are:

S. FORDHAM, *High Explosives and Propellants* (Pergamon, Oxford, 1966).

R. F. GOULD (Ed.), *Advanced Propellant Chemistry* (*Symposium in Detroit*, 1965) (American Chemical Society, 1966).

S. F. SARNER, *Propellant Chemistry* (Chapman & Hall, London, 1966).

S7 Fertilizers

In this field all matters relating to agriculture and horticulture are, of course, relevant, but these references have been necessarily limited to the main subject. Before fertilizers can be understood, however, some knowledge of the soil itself is necessary and this has been taken into account.

Books

E. L. WORTHERN and S. R. ALDRICH, *Farm Soils: their fertilization and management*, 5th edn. (1956). Very practical.

G. H. COLLINGS, *Commercial Fertilizers*, 5th edn. (McGraw-Hill, New York, 1955).

S. L. TISDALE and W. L. NELSON, *Soil Fertility and Fertilizers*, 2nd edn. (Macmillan, New York, 1966). A comprehensive treatise on the fundamental concepts of soil fertility and fertilizer manufacture and use—best read after some knowledge of soils.

D. P. HOPKINS, *Chemicals, Humus and the Soil* (Faber & Faber, London, 1956). A simple introduction.

J. S. REMINGTON and W. FRANCIS, *The Manure and Fertilizer Notebook*, 4th edn. (Leonard Hill, London, 1953). The simplest introduction.

K. PAISLEY, *Fertilizers and Manures* (Collingridge, London, 1960) deals with fundamentals in a very practical manner.

Fertilizer Statistics (annually), the Fertilizer Manufacturer's Association, London.

Fertilizers: an annual review of world production, consumption and trade.

Journals

Agricultural Chemicals (monthly), Industry Publications, Caldwell, NJ—deals with the whole range of agricultural questions with book reviews, news of industry, technical articles, market research, government activities, current pest outbreaks—mainly the United States, but with an international section.

Agriculture (monthly), Ministry of Agriculture, Whitehall Place, London, SW 1—has technical papers, review articles, book reviews, and market research.

Agricultural History Review (twice yearly), British Agricultural Society, St. Hilda's College, Oxford.

Journal of Agricultural Science, Cambridge University Press, Bentley House, 200 Euston Rd., London, NW 1—original papers.

Farm and Garden Contractor, National Association of Agricultural Contractors, 140 Bensham Lane, Thornton Heath, Surrey.

Research Stations

The Agricultural Research Council, Cunard Building, 15 Regent St., London, SW 1, has direct control of over twenty research stations and administers funds for more than twenty others. The following are particularly relevant to this field:

Unit of Experimental Agronomy, Oxford University.
Rothamsted Experimental Station, Harpenden, Herts.
Macaulay Institute for Soil Research, Aberdeen.
John Innes Institute, Bayfordbury, Hertford (Horticulture).
East Malling Research Station, Nr. Maidstone, Kent.
Agricultural and Horticultural Research Station, Long Ashton, Bristol.
Scottish Horticultural Research Institute, Invergowrie, Dundee.
Agricultural Economics Research Institute, Parks Road, Oxford.

Other research stations are, of course, maintained by the large industrial companies interested in products for agriculture and horticulture.

Trade Associations

Association of British Organic and Compound Fertilizers, 5–7 Houndsditch, London, EC 3.
British Sulphate of Ammonia Federation, 24–30 Gillingham St., London, SW 1.
Fertilizer Manufacturers' Association, 44 Russell Sq., London, WC 1.
Superphosphate Manufacturers' Association, 44 Russell Sq., London, WC 1.
Horticultural Trades Association, 58 Mark Lane, London, EC 3.

Associated Manufacturers of Veterinary and Agricultural Products, Alembic House, 93 Albert Embankment, London, SE 1.

There is also an association dealing with the application and necessary equipment, the National Association of Agricultural Contractors, 140 Bensham Lane, Thornton Heath, Surrey.

In addition there are the learned and professional societies:

The Fertiliser Society, Alembic House, 93 Albert Embankment, London, SE 1. Publishes *Proceedings*.

British Society of Soil Science, c/o School of Agriculture, Sutton Bonnington, Loughborough.

Soil Association, New Bells Farm, Haughley, Stowmarket, Suffolk.

Agricultural Economics Society, 7 Redlands Rd., Reading.

Women's Farm and Garden Association, Courtauld House, Byng Place, London, WC 1. Publishes newsletters (5 per year), *Year Book*, *Careers Book*.

Agricultural Educational Association, c/o Long Ashton Research Station, Bristol.

Also the following are of general interest to the public:

Royal Agricultural Society of England, 35 Belgrave Sq., London, SW 1. Publishes biennial *Review*, annual *Journal*.

Royal Highland and Agricultural Society of Scotland, 8 Eglinton Crescent, Edinburgh, 12. Publishes biennial *Transactions*.

Royal Ulster Agricultural Society, Belmont Show Grounds, Belfast, 9. Publishes show catalogues (3 per year).

Royal Welsh Agricultural Society, Llanelwedd, Builth Wells.

Royal Horticultural Society, Vincent Sq., London, SW 1. Publishes monthly *Journals* and *Proceedings* twice a year.

Royal Caledonian Horticultural Society, 44 Melville St., Edinburgh, 3.

S8 Firefighting Agents

Book

A. M. Cameron, *Chemistry in Relation to Fire Risk and Fire Extinction*, 3rd edn. (Pitman, London, 1948). Describes the

hazards and finally deals with fire extinguishers and fire proofing.

Further information can be obtained from the Fire Research Station, Boreham Wood, Herts., which issues technical papers each year and an annual bibliography of world literature on the subject.

Trade Associations

Fire Extinguisher Trades Association, Sec. W. A. Partridge, 74 Exmoor Drive, Worthing.

Industrial Fire Protection Association, 36 Ebury St., London, SW 1.

Journal

Fire (monthly), British Fire Services.

S9 Fireproofing Agents

There is no association or journal devoted specifically to fireproofing agents as these are included in more general headings such as textiles (fireproofing and flameproofing garments, furnishings, fabrics, etc.), wood (for fireproofing timber for building), and so on, but much information on the subject can be obtained from the following:

Books

J. E. Ramsbottom, *The Fireproofing of Fabrics* (HMSO, London, 1947).

R. W. Little, *Flameproofing Textile Fabrics*, A. F. S. Monograph 104 (Reinhold, New York, 1947).

Journal

Fire (monthly), British Fire Services.

Trade Association

Industrial Fire Protection Association, 36 Ebury St., London, SW 1.

Research Association

The Fire Research Station, Boreham Wood, Herts. Leaflets are issued at irregular intervals, also an annual bibliography of world literature on the subject.

S10 Foodstuffs Additives

In food processing chemicals are sometimes added to retain or improve colour, flavour, appearance, texture, or nutritive value, to prevent deterioration, to assist the large-scale production of materials of uniform quality, to improve packaging and distribution, or to make the food more easily and conveniently prepared in the home. The use of such additives is controlled by laws which vary from country to country.

Books

M. Pyke, *Food Science and Technology* (John Murray, London, 1964). Pages 154–60 give an outline of additives.

F. C. Blanck (Ed.), *Handbook of Food and Agriculture* (Reinhold, New York, 1955). Chap. 25 describes chemicals in foods.

G. Zweig (Ed.), *Analytical methods for Pesticides, Plant Growth Regulators and Food Additives* (Academic Press, New York, 1964). Food additives are described in Vol. I (chap. 4) and Vol. III (chaps. 22–4).

W. H. Butz and H. J. Noebels (Eds.), *Instrumental Methods for the Analysis of Food Additives* (Interscience, New York, 1961).

More recent work can be followed by reference to the publications of the Food Standards Committee of the Ministry of Food in London, and of the National Academy of Sciences in the National Research Council, Washington.

Journals

Food Engineering (monthly), international edition from 67–8 Jermyn St., St. James's, London, SW 1. Has flow sheets, new processes, unit operations, and directory.

Food Manufacture (monthly), Grampian Press, the Tower, Shepherd's Bush Rd., Hammersmith, W 6. Reviews the industry, new processes, equipment, packages, etc.

Food Trade Review (monthly), 7 Garrick St., London, WC 2. Reviews all matters regarding the industry.

Food Processing and Marketing (monthly), Tothill Press for the National Trade Press, 161–6 Fleet St., London, EC 4.

Food and Cosmetic Toxicology, the journal of the British Industrial and Biological Research Association (BIBRA).

Research Associations

British Food Manufacturing Industries Research Association, Randalls Rd., Leatherhead, Surrey. Publishes scientific and technical surveys.

British Industrial and Biological Research Association, Woodmansterne Rd., Carshalton, Surrey. Publishes *Food and Cosmetic Toxicology* and information bulletins, studies the hazards of additives of all kinds, not only for foods.

Trade Associations

Food Manufacturers Federation, 3–4 Lygar Place, London, SW 1. Review published monthly, also suppliers' guide.

Food Manufacturers Industrial Group, 3–4 Lygar Place, London, SW 1.

National Council of Concentrate Manufacturers, 58 Mark Lane, London, EC 3.

National Association of Frozen Egg Packers, 16 Duke St. Hill, London, SC 1.

National Association of Frozen Food Producers, 4 Lygar Place, London, SW 1.

General

Wine and Food Society, 2 Hyde Park Place, London, W 2, quarterly publication *Wine and Food.*

S11 Foundry Preparations

Information regarding these materials is scattered, and the needs of the section are gradually appreciated by experience within the industry. The following books and journals will give a general view of the practice within the foundry and of the chemicals of interest.

Books

J. L. Feirer, *General Metals* (McGraw-Hill, New York, 1959). A basic text book in metal working.

W. H. Salmon and E. N. Simons, *Foundry Practice* (Pitman, London, 1957).

S. E. Rusinoff, *Foundry Practices* (American Technical Society, 1955).

Journals

Foundry Trade Journal (weekly), Fuel and Metallurgical Journals Ltd., John Adam House, 17–19 John Adam St. Adelphi, London, WC 2. This is the official organ of the Association of Bronze and Brass Founders; the Light Metal Founders' Association; Foundry Trades Equipment and Supplies Association; and the National Society of Master Patternmakers.

The British Foundryman (monthly), Institute of British Foundrymen.

Trade Associations

Foundry Trade Equipment and Supplies Association, c/o Peat, Marwick, Mitchell & Co., Glen House, Stag Place, London, SW 1.

Association of Bronze and Brass Founders, c/o Heathcote & Coleman, 69 Harborne Rd., Birmingham, 15.

Light Metal Founders' Association, c/o Heathcote & Coleman, as above.

British Ironfounders' Association, 30 St. James's Sq., London, SW 1.

Scottish Ironfounders' Association, 142 St. Vincent St., Glasgow, C 2.

Council of Ironfoundry Associations, 14 Pall Mall, London, SW 1.

Ironfounders' National Confederation, 30 Union St., Birmingham, 2.

Malleable Ironfounders' Association, c/o Chamber of Commerce, Tudor House, Bridge St., Walsall, Staffs.

National Federation of Engineering and General Ironfounders, 8 Fredericks' Place, Old Jewry, London, EC 2.

National Ironfounding Employers Federation, as above.

National Light Castings Ironfounders Association, 142 St. Vincent St., Glasgow, C 2.

National and Midlands Ironfounders Association, c/o Heathcote & Coleman, 69 Harborne Rd., Birmingham, 15.

Professional and Educational Associations

National Foundry Craft Training Centre, c/o Heathcote & Coleman, 69 Harborne Rd., Birmingham, 15.

British Investment Casters' Technical Association, 5 East Bank Rd., Sheffield, 2. Publishes abstracts bimonthly and proceedings annually.

Institute of British Foundrymen, 137–9 Euston Rd., London, NW 1.

Research Associations

British Steel Castings Research Association, East Bank Rd., Sheffield, 2.

British Cast Iron Research Association, Bordesley Hall, Alvechurch, Birmingham, publishes *BCIRA Journal.*

S12 Fuel and Oil Additives

These are chiefly of interest in the motor car and aero-industries. Tetra-ethyl lead was probably the first important chemical additive to fuel oils. With the advent of better and more powerful engines there arose a need for better fuels and lubricating oils. In the later 1950's the Petroleum Industry used thousands of tons of chemicals each year. There are two chief purposes: (1) in refining processes, as catalysts for promoting reaction, or as solvents or acids for purifying, and (2) to improve final products, e.g. tetra-ethyl lead (anti-knock); oxidation inhibitors (reducing fuel gumming); anti-oxidants and corrosion inhibitors (help oils to withstand high temperatures); detergents (keeping engines clean); pour-point depressants (help cold starting); viscosity improvers (prevent oil thinning out at high temperatures); and several others.

Book

G. W. Himus, *Elements of Fuel Technology*, 2nd edn. (Leonard Hill, London, 1958).

Journals

Fuel (6 issues per year), Butterworths, 88 Kingsway, London, WC 2.

Fuel Abstracts (monthly), Institute of Fuel.

Petroleum: the journal of the European Oil Industry (six issues per year), Terminus Publications Ltd, Tanker House, 416 Kings Rd., Chelsea, London, SW 10.

Petroleum Times (monthly), international journal, Heywood Temple Industrial Publications Ltd., 33–4 Bowling Green Lane, London, EC 1.

Trade Associations

National Lubricating Oil and Grease Federation, 5–7 Houndsditch, London, EC 3.

Petroleum Information Bureau (and Petroleum Films Bureau), 4 Brook St., London, W 1. Publishes monthly newsletter.

Professional Associations

Institute of Fuel, 18 Devonshire St., Portland Place, London, W 1. Publishes monthly journal and abstracts.

Institute of Petroleum, 61 New Cavendish St., London, W 1. Publishes monthly journal and literature review monthly.

S13 Greases and Lubricants

The demands made upon modern lubricants by high-speed aircraft, rockets, and missiles create many new problems. The increased speeds of jet-aircraft demand lubricating agents which must work over a wider range of temperatures. They must be viscous enough at temperatures of several hundred °F, and yet be fluid enough at low temperatures (−65°F) to flow to the parts requiring lubrication. For special purposes lubricating greases are devised by mixing lubricating oils with metallic soaps. There is an overlap in the technology of this section and the preceding section S12 (Fuel and Oil Additives).

Books

R. C. Gunderson and A. W. Hart (Eds.), *Synthetic Lubricants* (Reinhold, New York, 1962).

A. Cameron, *Principles of Lubrication* (Longmans, London, 1966). A study of the theory with minimum mathematics.

E. A. Evans, *Lubricating and Allied Oils* (Chapman & Hall, London, 1963). A most readable book—chap. V deals with additives.

C. J. Boner, *Manufacture and Application of Lubricating Greases* (Reinhold, New York, 1954). Very comprehensive.

Journals

Transactions of the American Society of Lubrication Engineers (quarterly), known also as *ASLE Transactions.*

Lubrication Engineering (monthly), ASLE, Ill.

Trade Associations

National Lubricating Oil and Grease Federation, 5–7 Houndsditch, London, EC 3.

Scottish Lubricants Association, 7 West George St., Glasgow, C 2.

Professional Body

American Society of Lubrication Engineers, 838 Busse Highway, Park Ridge, Ill.

S14 Laboratory Chemicals and Reagents

This section of the industry has a rather special approach to its problems of supply and demand as it deals essentially with the supply of smaller quantities of a very wide range of products, a so-called "small-pack" industry. The techniques of marketing and packaging are therefore very important, the package becoming an appreciable item of the cost. On the technical side great emphasis is laid upon working to a high state of purity or to a rigid specification.

A knowledge of analytical chemistry and techniques is therefore of great importance, and experience of laboratory practice is essential for an understanding of the problems involved.

Below, therefore, are listed a few books and journals dealing with these subjects in the hope that they may introduce readers to this interesting section of the Chemical Industry.

Books

P. S. Diamond and R. F. Denman, *Laboratory Techniques in Chemistry and Biochemistry* (Butterworths, London, 1966).

D. D. PERRIN, W. F. ARMAREGO, and D. R. PERRIN, *Purification of Laboratory Chemicals* (Pergamon, Oxford, 1966).

I. M. KOLTHOFF, P. J. ELVING, and E. B. SANDALL (Eds.), *Treatise on Analytical Chemistry* (Interscience, New York, 1959–66). In three parts: (1) Theory and Practice, (2) Analytical Chemistry of Inorganic and Organic Compounds, (3) Analytical Chemistry in Industry. Each part has several volumes, most comprehensive—still in production.

A corresponding work on the British side, not so voluminous but authoritative, based on the work of the Analytical Committee of ICI, is C. R. N. STROUTS, H. N. WILSON, and R. T. PARRY-JONES (Eds.), *Chemical Analysis*, in 3 vols. (Clarendon, Oxford, 1962).

S15 Metal Treatment and Anti-corrosive Products

This section deals with all chemicals and processes which protect the metal surface from the oxidation reactions to which it is constantly exposed, so it includes coatings (including paints), chemicals adsorbed on the surface (e.g. benzotriazole for the protection of copper), and electroplating. A wide range of chemical products is therefore of interest, and includes, of course, those used also to enhance the appearance or polish of the metal.

Books

P. A. CARTWRIGHT, *Metal Finishing Handbook* (Blackie, London, 1950).

R. M. BURNS, and W. W. BRADLEY, *Protective Coatings for Metals* (Reinhold, New York, 1955).

W. J. McG. TEGART, *The Electrolytic and Chemical Polishing of Metals*, 2nd edn. (Pergamon, Oxford, 1959).

B. F. BLUNDELL, *An Introduction to Industrial Finishing Equipment* (Pergamon, Oxford, 1965).

W. WIEDERHOLT, *The Chemical Surface Treatment of Metals* (English translation edited by W. E. Cattley) (Draper, Teddington, 1965).

Handbook of High Vacuum Engineering (Reinhold, New York, 1963). Chap. 13 deals with coating techniques.

Journals

Anti-corrosion Methods and Materials, new journal (monthly), Grampian, London.

Electroplating and Metal Finishing (monthly), Robt. Draper Ltd., 85 Udney Park Rd., Teddington, Middlesex, for the Metal Finishing Association.

Electrochemical Society Journal (monthly), 30 East 42nd St., New York—papers devoted to the applications and engineering aspects of electrochemistry covering therefore the traditional fields: electrode processes, electrolytic conductivity, and the behaviour of ionized gases. It is proposed in the near future to publish in 3 parts: (A) Electrochemical Science; (B) Solid-state Science, i.e. electronics, dielectrics, metallurgical applications; (C) Electrochemical Technology, which is the present coverage.

Industrial Finishing (monthly), Arrow Press Ltd., Stamford House, 65–6 Turnmill St., London, EC 1.

Institute of Metals Journal, 17 Belgrave Sq., London, SW 1.

Journal of Metals (monthly), American Institute of Mining, Metallurgical, and Petroleum Engineers, 345 East 47th St., New York.

Transactions of the American Society for Metals (quarterly), Metals Park, Ohio.

Also the following dealing with specific metals:

Cobalt (quarterly), Centre d'Information du Cobalt, 35 rue des Colonies, Brussels.

Copper (quarterly), Copper Development Association, 55 South Audley Sq., London, W 1.

Lead Abstracts, Lead Development Association, 34 Berkeley Sq., London, W 1.

Trade Associations

Metal Finishing Association, 2–4 Carey Lane, London, EC 2.

British Association of Corrosion Engineers, PO Box 25, Trafalgar Sq., London, WC 2.

Information on particular metals can be obtained from the Metal Information Bureau, London, W 1.

Metal Finishing Suppliers' Association Inc., 405 Lexington Ave., New York.

Professional Bodies

Institute of Metal Finishing, 32 Great Ormond St., London, WC 1, publishes transactions (5 per year).

British Joint Corrosion Group—sponsored by the Iron and Steel Institute, Society of Chemical Industry, Institute of Metals, and Institute of Metal Finishing—to promote discussion, publishes the *British Corrosion Journal.* Administered by SCI, 14 Belgrave Sq., London, SW 1.

Institute of Metals, 17 Belgrave Sq., London, SW 1, publishes a journal and metallurgical abstracts.

London Metallurgical Society, 17 Belgrave Sq., London, SW 1.

S16 Paints and Surface Coatings

In modern times most manufactured articles are given some form of surface coating (a) to protect them from outside destructive agents (e.g. air, water, acid, etc.), and (b) to give them an attractive appearance, usually referred to respectively as the protective function and the decorative effect. This is usually achieved by the application of paints, varnishes, lacquers, and related materials. In the broadest sense of the term "surface coatings" there should also be included metals, alloys, metallic oxides, or salts, which are used in the protection of metallic surfaces, e.g. a surface-layer of zinc protects steel as in galvanizing; aluminium can be "anodized", which deposits a protective layer of aluminium oxide by electrolysis. Such processes, however, are dealt with in S15, Metal Treatment and Anti-corrosive Products. It should be noted that paints are also used on metals to protect them against corrosion during manufacture.

This section therefore deals with the manufacture of paints, varnishes, lacquers, and related products, and one of the important related products is the manufacture of printing inks. Both the manufacture of paints and of printing inks have a similar technological background, and many of the raw materials of the two industries are the same or closely related.

(a) The Paint Industry

Books

For many years the outstanding book on surface coatings has been: J. J. Mattiello (Ed.), *Protective and Decorative Coatings* (Wiley, New York, 1941). This covers the whole range of paints, printing inks, and pigments in 6 volumes.

Since then the following authoritative books have appeared:

H. W. Chatfield (Ed.), *The Science of Surface Coatings* (Benn, London, 1962).

W. von Fischer (Ed.), *Paint and Varnish Technology* (Hafner, New York, 1964).

D. H. Parker, *Principles of Surface Coating Technology* (Interscience, New York, 1965).

P. Nylen and E. Sunderland, *Modern Surface Coatings* (Interscience, New York, 1965). A particularly scholarly production and although published in English in America is based on experience in Sweden.

A. Y. Drinberg, E. S. Gurevich, and A. V. Tikhomirov, *Technology of Non-metallic Coatings* (translated from Russian) (Pergamon, Oxford, 1960).

The best introduction to the subject for the young man entering the industry and studying for an academic qualification is the text-book series *Paint Technology Manuals*, issued by the Oil and Colour Chemists' Association: Part I, *Non-convertible Coatings*; Part II, *Solvents, Oils, Resins, Driers*; Part III, *Convertible Coatings*; Part IV, *Application of Surface Coatings*; Part V, *The Testing*

of Paints; Part VI, *Pigments, Dyestuffs and Lakes*. Each volume complete in itself (Chapman & Hall, London, 1961–6), on behalf of the Oil and Colour Chemists' Association.

For a simple primer to introduce painters to the technology:

L. F. J. Tibb, *Painters' Craft Science* (Cleaver-Hume, London, 1954).

As a laboratory handbook containing much practical data:

W. G. B. Mills, *Paint Chemists' Handbook* (Scott Greenwood, London, 1962).

As a general buyers' guide with much information about the industry:

Paint Trade Manual of Raw Materials and Plant (1966) (the Journal, Paint Technology).

A general guide to the industry is *The Paint, Oil and Colour Year Book* (Scott, Greenwood, London), which gives a wealth of information about the products, raw materials, equipment, containers, paint and printing ink manufacturers, associations, and so on.

Journals

Journal of the Oil and Colour Chemists' Association (monthly) is the leading scientific and technical journal in these industries.

The Paint, Oil and Colour Journal (weekly) gives the technical and commercial events of the industries, with useful statistics and frequent technical articles (83–6 Farringdon St., London, EC 4).

The Oil, Paint and Drug Reporter (weekly), a chemical marketing newspaper, does the same for the United States but covers a wider field (e.g. drugs, fertilizers, pesticides, etc.).

Paint Technology (monthly), Sawell Publications, 4 Ludgate Circus, London, EC 4, gives a more technical coverage.

Industrial Finishing (monthly), Arrow Press, London, also covers plating as well as paint.

Surface Coatings (Industrial finishes and their applications) (monthly), Broadwall Publications, London.

Journal of the American Oil Chemists' Society (monthly), 35 East Wacker Drive, Chicago, Ill.

Trade Associations

Paint Manufacturers and Allied Trades Association, 1 Rule St., Wandsworth Rd., London, SW 8.

The Paint Makers' Association of Great Britain, Prudential House, Wellesley Rd., Croydon, Surrey.

National Marine Paint Association, St. Stephen's House, Westminster, London, SW 1.

Scottish Association of Paint Manufacturers, 128 Hope St., Glasgow, C 2.

Bristol and West Paint Manufacturers' Association, Hon. Sec. G. A. Piercy, 10 Dial Hill Rd., Clevedon, Somerset.

Professional Bodies

Oil and Colour Chemists' Association, Wax Chandlers' Hall, Gresham St., London, EC 2, has local sections in all busy centres in the United Kingdom, and also in Australia and South Africa.

Birmingham Paint, Varnish, and Lacquer Club, Sec., F. Suddaby, Permoglaze Ltd., James Rd., Tyseley, Birmingham, 11.

Borough Oil and Colour Students' Association, Hon. Sec. D. E. Eddowes, Scott, Greenwood & Son Ltd., 83–6 Farringdon St., London, EC 4.

Research Association

The Research Association of Paint, Colour, and Varnish Manufacturers, Waldegrave Rd., Teddington, Middlesex. They issue an abstract review monthly.

The following deal with special activities within the industry: Paint Industries Club, Hon. Sec. R. M. Esdarle, 1 Kelvin Way, Crawley, Sussex (social), and Paint Trade Benevolent Fund, Hon. Sec. E. G. Sangster, St. Stephen's House, Westminster, SW 1.

(b) The Printing Ink Industry

Books

R. F. Bowles (Ed.), *Printing Ink Manual*, commissioned by the Technical Training Board of the Society of British Printing Ink Manufacturers (Heffer, Cambridge, 1961).

H. J. Wolfe, *Printing and Litho Inks*, 5th edn. (MacNair-Dorland, New York, 1957).

L. M. Larsen, *Industrial Printing Inks* (Reinhold, New York, 1962).

E. A. Apps, *Printing Ink Technology* (Leonard Hill, London, 1958).

Printing Ink Manufacturers and their interests are also covered in *The Paint, Oil and Colour Year Book* (see page 118).

Journals

The British Ink Maker (quarterly), the official journal of the Society of British Printing Ink Manufacturers, Batiste Publications Ltd., Drummond House, 203 Gower St., London, NW 1.

Journals mentioned under Paints all cater also to a greater or lesser extent for the Printing Ink Industry.

Readers of this section will also be interested to keep contact with the users of printing inks, namely, the Printing Industry, and the following journals are relevant:

Printing Technology, the proceedings of the Institute of Printing, 44 Bedford Rd., London, WC 1.

Printing Trades Journal (monthly), Benn Bros., Bouverie House, Fleet St., London, EC 4.

The Printing World, Stonhill & Gillis Ltd., 296–302 High Holborn, London, WC 1.

Archiv für Druck Technik (every 2 months), P. Keppler, Heusenstamm, Berlin.

The British Printer (monthly), Maclean Hunter Ltd., 30 Old Burlington St., London, W 1.

Graphic Technology (quarterly), review of the printing and allied industries, Mimram Books Ltd., Caxton Hill, Ware Road, Hertford.

Gravure (monthly), devoted to all types of gravure printing and converting, Graphic Magazines Inc., 61 Hilton Ave., Garden City, New York.

Print in Britain (monthly), National House, 60 Wardour St., London, W 1.

Paper and Print (quarterly), Stonhill & Gillis Ltd., 296–302 High Holborn, London, WC 1.

Trade Association

Society of British Printing Ink Manufacturers, Burley House, Theobalds Rd., London, WC 1.

Professional Body

Oil and Colour Chemists' Association (see page 119).

Research Association

The Printing, Packaging, and Allied Trades Research Association (PATRA), Patra House, Randalls Rd., Leatherhead, Surrey.

S17 Pest Control Products

In the Chemical Industry classification these are divided into three separate groups of products

(a) Fungicides.
(b) Weed Killers.
(c) Insecticides.
(d) Others.

This is a useful device for considering the manufacturing processes and units involved, but the separation into these groups is not so easy in dealing with the application of pesticides. Some books, journals, and organizations cover the whole field, while there are others which specialize in one or more of the above sections. Here the general field is first considered and then each section separately.

(a) General

Books

H. Martin, *The Scientific Principles of Crop Protection*, 4th edn. (Arnold, London, 1959).

E. Holmes, *Practical Plant Protection* (Constable & Co., London, 1955).

Journals

World Crops (quarterly), an international journal of agriculture. Grampian Press Ltd., The Tower, Brook Green Rd., Hammersmith, London, W 6.

Agricultural Chemicals (monthly), Industry Publications Inc., Caldwell, NJ.

Pest Control (monthly), Trade Magazines Inc., 1900 Euclid Ave., Cleveland, Ohio.

International Pest Control (bimonthly), deals with crop protection, public health, wood preservations, Rhodes Industrial Magazines, Ltd., 36 Clerges St., London, W 1.

Public Health (bimonthly), the Society of Medical Officers of Health, Tavistock House South, Tavistock Sq., London, WC 1.

Sanitarian (monthly), the Association of Public Health Inspectors, 19 Grosvenor Rd., London, SW 1.

An interesting development in the United States is the appearance of a new journal, *Pesticides Monitoring Journal*, to be published quarterly by the Federal Committee in Pest Control, Atlanta, Ga.

Trade Associations

Association of British Manufacturers of Agricultural Chemicals, Alembic House, 93 Albert Embankment, London, SE 1, dealing with all problems on pesticides related to growing crops.

Industrial Pest Control Association, Alembic House, 93 Albert Embankment, London, SE 1, dealing with pesticides related to problems of health and hygiene including stored products.

National Association of Agricultural Contractors, 140 Bensham Lane, Thornton Heath, Surrey, dealing with the application of pesticides and other products on the large scale.

Research Associations

All the Agricultural Research Stations listed under S7, Fertilizers, carry out work also on pesticides, and the large manufacturers such as ICI, Shell, Fisons, Geigy, and others maintain large research stations carrying out original research.

Note also the Timber Research and Development Association, St. John's Rd., Tyler's Green, High Wycombe, Bucks.

Professional Body

Society of Chemical Industries Pesticides Group, 14 Belgrave Sq., London, SW 1.

(b) FUNGICIDES

Books

E. GRAMM, P. BOVIAN, and C. STAPEL, *Recognition of Diseases and Pests of Farm Crops* (Heffer, Cambridge, on behalf of the Danish Agricultural Information and Advisory Aids Service, 1958). Has 112 coloured plates with explanations in Danish, French, and English.

A. BEAUMONT, *Diseases of Farm Crops* (Collingridge, London, 1959).

F. T. Brooks, *Plant Diseases*, 2nd edn. (O.U.P., London, 1953).

J. E. van der Plank, *Plant Diseases* (Academic Press, New York, 1963), describes the South African practice.

H. Martin (Ed.), *Insecticide and Fungicide Handbook*, 2nd edn., issued by the British Insecticidal and Fungicidal Council (Blackwell, Oxford, 1965).

Professional Body

British Mycological Society, Plant Breeding Institute, Cambridge. Publishes *Transactions*.

(c) Herbicides

Books

W. C. Muenscher, *Weeds* (Macmillan, New York, 1955).

E. K. Woodford and S. A. Evans (Eds.), *Weed Control Handbook*, 4th edn., issued by the British Weed Control Council (Blackwell, Oxford, 1965). A comprehensive guide kept up to date at intervals of about 2 years.

G. H. Bates, *Weed Control* (Spon, London, 1955). A "popular" edition.

Professional Body

British Weed Control Council, 95 Wigmore St., London, W 1.

(d) Insecticides

Books

H. W. and M. Miles, *Insect Pests of Glass House Crops*, 2nd edn. (Crosby Lockwood, London, 1948).

F. G. W. and M. Jones, *Pests of Field Crops* (Arnold, London, 1964).

R. L. Metcalf, *Organic Insecticides* (Interscience, New York, 1955).

T. F. West and G. A. Campbell, *DDT and newer Persistent Insecticides*, 2nd edn. (Chapman & Hall, London, 1950).

Journals

Entomologists' Gazette (monthly), E. W. Classey, 353 Henworth Rd., Hampton, Middlesex.

The Entomologist, the Journal of the Society for British Entomology, British Trust for Entomology Ltd., 41 Queen's Gate, London, SW 7.

Entomologists' Monthly Magazine, 7 Thorncliffe Rd., Oxford.

Professional Body

Royal Entomological Society of London, 41 Queen's Gate, London, SW 7, publishes *Transactions* and *Proceedings*.

S18 Pharmaceutical Preparations

This refers essentially to the synthesis, development, and manufacture of synthetic drugs and their subsequent standardization. It is the chemical synthesis which is the essential task of the pharmaceutical industry, although all companies engaged in this work also carry out researches in the study of diseases and the effect of drugs upon the human body. Generally speaking they supply active ingredients in standardized form to the pharmacist, who will compound them according to medical prescriptions.

Pharmacology is the science covering all knowledge of drugs and their effect on the human and animal body, with special reference to their mechanism in the treatment of disease, to which is given the name "therapeutics". Therapeutics is therefore a subdivision of pharmacology. Other subdivisions are pharmacy (as above described) and toxicology (the study of poisonous effects on the living body).

It is true, therefore, that the chemist interested in this field will gain greatly from a knowledge of pharmacology in its widest

sense, but the books recommended below deal essentially with the synthesis of new and existing drugs and closely allied subjects.

Books

G. M. Dyson and P. May, *May's Chemistry of Synthetic Drugs*, 5th edn. (Longmans, London, 1959).

H. R. Fleck, *Synthetic Drugs* (Cleaver-Hume Press, London, 1955).

J. A. Gunn, *Introduction to Pharmacology and Therapeutics*, 2nd edn. (OUP, London, 1958).

S. M. Brooks, *Basic Facts of Pharmacology* (Saunders, Philadelphia, 1963).

Journals

Pharmaceutical Journal (weekly), the Pharmaceutical Society of Great Britain, 17 Bloomsbury Sq., London, WC 1.

British Journal of Pharmacology and Chemotherapy (9 issues per year, made up in 3 vols.), British Pharmacological Society, Tavistock Sq., London, EC 1.

Current Medicine and Drugs (monthly), Butterworths, London.

Chemist and Druggist (weekly), Morgan Bros. Ltd., 28 Essex St., London, WC 2.

Industrial Medicine and Surgery (monthly), 1305 St. Clair Ave., Sheboygan, Wis., USA—an international journal of medicine in industry.

British Medical Journal (weekly), BMA, Tavistock Sq., London, WC 1.

The Lancet (weekly), 7 Adam St., Adelphi, London, WC 2.

Manufacturing Chemist and Aerosol News (monthly), Grampian Press, the Tower, 229–43 Shepherd's Bush Rd., London, W 6.

British Pharmacopeia, Pharmaceutical Press, 7 Bloomsbury Sq., London, WC 1, 1963, ed. with addenda 1963 and 1966.

Trade Associations

Association of the British Pharmaceutical Industry, 195 Knightsbridge, London, SW 7. Publishes *Annual Report*.

Association of Manufacturing Chemists, 14–17 Holborn Viaduct, London, EC 1.

Proprietary Articles Trade Association, 150 Southampton Row, London, WC 1. Publishes PATA quarterly record and PATA year book.

Proprietary Association of Great Britain, 623 Victory House, Southampton Row, London, WC 1. Publishes *Annual Report*.

Professional Body

Pharmaceutical Society of Great Britain, 17 Bloomsbury Sq., London, WC 1.

S19 Photographic Chemicals

With the application of photographic processes into almost every form of publicity—television, cinema, printing—to say nothing of the widespread interest in photography by the man in the street—the chemicals required for processing assume very large tonnages, and they must be made in a high state of purity.

We are not concerned here with the art of photography, but rather with the chemical processes and chemical products involved, and the following references are restricted with this in view. Nevertheless, it will be readily appreciated that the makers of chemicals for photography will understand their problems all the better if they are also "skilled in the art" of photography itself.

Books

C. E. K. Mees and T. H. Jones (of Kodak Research Laboratories) (Eds.), *The Theory of the Photographic Process* (Macmillan, New York, 1966). A most valuable book for more advanced reading with a wealth of literature references.

G. Russell, *Chemical Analysis in Photography* (Focal Press, London, 1965). This is the first book on the subject, giving valuable insight into the nature and properties of photographic material.

E. MYTUM, *Photographic materials* (MacDonald & Evans, London, 1956). A guide to the syllabus of the City and Guilds examinations in photography.

D. H. O. JOHN and G. T. J. FIELD (of May & Baker Research Laboratories), *A Text book of Photographic Chemistry* (Chapman & Hall, London, 1963). A most valuable introduction, and chap. 12 guides the reader through the scattered literature of photography and photographic chemicals as an aid to further study.

P. GLAFKINDER, *Photographic Chemistry*, 2 vols., translated from the French by K. M. HORNSBY (Fountain Press, London, 1958–60). A complete survey of the subject discussing theory as well as the properties of materials.

Journals

The Journal of Photographic Science, official monthly publication of the Royal Photographic Society of Great Britain.

The Photographic Journal (monthly), RPS.

The Photographer, journal of the Institute of Incorporated Photographers.

Professional Bodies

Royal Photographic Society of Great Britain, 16 Princes Gate, London, SW 7.

Institute of Incorporated Photographers, 38 Bedford Sq., London, WC 1.

S20 Pigments (a) Coloured, (b) White

The biggest single user of pigments, both coloured and white, is the paint industry. Pigments are used, however, in a variety of other industries, notably in printing inks, rubber, plastics, linoleum, textile printing and padding, and paper coating. Pigments may be inorganic (as, for example, prussian blue, chrome yellows,

ultramarine, to name only a few) or organic, in which case they may be regarded as a specialized branch of dyestuff manufacture resulting in products which are insoluble in water as distinct from dyes, which are, of course, applied to textiles from an aqueous solution. It will be noted that the word "pigment" does not occur in the name of any of the organizations in the industry, the more general word "colours" still being used.

Books

H. A. LUBS (Ed.), *Chemistry of Synthetic Dyes and Pigments* (Reinhold, New York, 1955).

A. W. C. HARRISON, *Manufacture of Lakes and Precipitated Pigments*, 2nd edn. (Leonard Hill, London, 1957).

J. J. MATTIELLO (Ed.), *Protective and Decorative Coatings* (Wiley, New York, 1941) (Vol. II deals with pigments).

Pigments, Dyestuffs and Lakes, being Vol. VI in the series Paint Technology Manuals issued by the Oil and Colour Chemists' Association (Chapman & Hall, London, 1966).

L. S. PRATT, *Chemistry and Physics of Organic Pigments* (Wiley, New York, 1947).

The Paint, Oil and Colour Year Book (see page 118), also deals with the Pigment Industry.

Journals

The Pigment Industry is catered for also by the journals mentioned under S16, Paints and Surface Coatings.

Trade Associations

The British Colour Makers' Association, Alembic House, 93 Albert Embankment, London, SE 1.

The British Artists' Colour Manufacturers' Association, 6 Holborn Viaduct, London, EC 1.

Professional Body

Oil and Colour Chemists' Association, Wax Chandlers' Hall, Gresham St., London, EC 2.

Research Association

The Research Association of the Paint, Colour and Varnish Manufacturers, Paint Research Station, Waldegrave Rd., Teddington, Middlesex. They issue an *Abstract Review* monthly to member firms.

S21 Plastics

The name "plastic" is given to any material which at some stage of its processing becomes plastic or malleable and can be moulded into a shape which it then retains. Plastics have assumed such great importance recently because of their stability, and the fact that they can, in many instances, replace the traditional materials of construction and fabrication: wood, metals, glass, ceramics, leather, textiles. There are now many different kinds of plastic on the market with different characteristics which enable them to meet a wide variety of requirements.

Books

H. R. Fleck, *Plastics, Scientific and Technological*, 3rd edn. (Temple Press, London, 1951).

F. Bueche, *Physical Properties of Polymers* (Interscience, New York, 1962).

J. A. Brydson, *Plastics Materials* (Iliffe, London, 1966), with a good modern bibliography.

H. R. Simonds and J. M. Church, *A Concise Guide to Plastics* (Reinhold, New York, 1963).

V. E. Yarsley and E. G. Couzens, *Plastics in the Service of Man* (Penguin, 1956).

In addition there are many good books on individual plastics too numerous to quote here, but worth seeing if the reader's interest becomes engaged in one type of plastic. There are, for instance, authoritative books on polythene, fluorocarbons, polyamides, polyurethanes, styrene polymers and co-polymers, epoxy resins, PVC, PF and UF resins, and so on.

Journals

Plastics (monthly), Heywood Temple Industrial Publications, 33–9 Bowling Green Lane, London, EC 1.

British Plastics (monthly), Iliffe, London.

Journal of Applied Polymer Science (monthly), Interscience, 20th St., Easton, Pa.

Modern Plastics (monthly), McGraw-Hill, New York.

Plastics Abstracts (patents and literature), Plastics Investigations, 31 Canonsfield Rd., Welwyn, Herts.

Plastics, Rapra Abstracts (monthly), Rubber and Plastics Research Association of Great Britain.

Plastics Technology, Plastics Processing, Bill Brothers Publishing Corpn., New York.

Polymer, the chemistry, physics, and technology of high polymers (monthly), Butterworths, London.

Trade Associations

British Cellular Rubber and Plastics Manufacturers' Association, 236 Royal Exchange, Manchester.

British Plastics Federation, 47–8 Piccadilly, London, W 1. Publishes a monthly bulletin.

Plastics and Allied Trades Protection Association, 4 Charterhouse Sq., London, EC 1.

Association of Plastic Cable Makers, 381–99 Salesbury House, London Wall, London, EC 2.

Association of Plastic Line Manufacturers and Contractors, 13 Bedford Row, London, WC 1.

British Seamless Rubber and Plastics Manufacturers Association, 236 Royal Exchange, Manchester, 2.

Plastic Houseware Manufacturers Association, 11 Ironmonger Lane, London, EC 2.

Professional Body

The Plastics Institute, 6 Mandeville Place, London, W 1. Publishes *Transactions* and *Journal*, bimonthly.

Research Association

Rubber and Plastics Research Association of Great Britain, Shawberry, Shrewsbury, Shropshire. Publishes *Rubber Abstracts* and *Bulletin*.

S22 Plasticizers

These are compounds which are added to plastics or to surface coatings containing resins which would otherwise produce films too brittle on drying. Their function (as their name implies) is to give greater plasticity or flexibility to the finished product, and they have attained a position of considerable importance with the spectacular growth of the plastics industry and the increased use of polymeric resins in the surface-coating industries.

The needs of the Plasticizer Industry are met by the journals and organizations listed under the Plastics Industry (S21) and the Paint Industry (S20), but the following books deal more specifically with plasticizers: D. N. Buttery, *Plasticizers*, 2nd edn. (Cleaver-Hume, London, 1957), and I. Mellan, *Behaviour of Plasticizers* (Pergamon, Oxford, 1963).

S23 Refrigerants and Aerosol Propellants

With the greatly increased demand for domestic refrigerators and freezers and the development of refrigerated food transport in

trucks and trailers, railway cars and ships, the supply of refrigerants for use in the various appliances assumes great importance. The refrigerants are the working fluids used to carry away the heat from the region being cooled.

The "aerosol" pressurized container uses compounds of similar structure and properties, and everywhere such "aerosols" are seen to be used for the packing of all sorts of products, from shaving creams to insecticides. In this case the propellant gas, on being released into the atmosphere, quickly volatilizes, causing the product to disperse in small particles, which is, of course, what is understood by the "aerosol" effect. Long-term forecasts indicate that there is an expansion potential in the aerosol market of two to three times the present output, which is not surprising considering the range of products to which it is at present applied—insecticides, waxes, and polishes, air-fresheners, starches, oven cleaners, shaving creams, coatings, deodorants, perfumes, hair sprays, and many others.

Books

S. A. Anderson, *Automatic Refrigeration* (MacLaren, London, 1959). Based on experience in Denmark.

R. J. Dossat, *Principles of Refrigeration* (Wiley, New York, 1961).

Bibliographic Guide to Refrigeration, 1953–60 (Pergamon, Oxford).

Bibliographic Guide to Refrigeration, 1961–64 (Pergamon, Oxford).

A. Herzka and J. Pickthall, *Pressurized Packaging (Aerosols)*, 2nd edn. (Butterworths, London, 1961).

H. R. Shepherd (Ed.), *Aerosols, Science and Technology* (Interscience, New York, 1961).

Trade Associations

British Refrigeration Association, 1 Lincolns Inn Fields, London, WC 2.

British Aerosol Manufacturers' Association, Alembic House, 93 Albert Embankment, London.

Professional Body

Institute of Refrigeration, 30334 New Bridge St., London, EC 4, publishes *Proceedings* annually.

S24 Rubber Chemicals

The literature and organizations of the Rubber Industry itself provide the information regarding chemicals used within the industry.

Books

P. SCHIDROWITZ and T. R. DAWSON (Eds.), *History of the Rubber Industry* (Heffer, Cambridge, 1952), compiled under the auspices of the Institution of the Rubber Industry.

H. BARRON, *Modern Rubber Chemistry*, 2nd edn. (Hutchinsons, London, 1947), a well-known text-book.

D. W. HUKE, *Introduction to Natural and Synthetic Rubbers* (Hutchinsons, London, 1961).

H. L. FISHER, *Rubber and its Use* (Macmillan, London, 1941), a popular introduction to be read at one sitting.

A. S. CRAIG, *Rubber Technology: a basic course* (Oliver & Boyd, Edinburgh, 1963), probably the best modern introduction.

W. J. NAUNTON, *The Applied Science of Rubber* (Arnold, London, 1961), prepared with the approval of the Institution of the Rubber Industry.

M. MORTON (Ed.), *Introduction to Rubber Technology* (Reinhold, New York, 1959).

J. Van ALPHEN *et al.* (in English and German), *Rubber Chemicals* (Elsevier, Amsterdam, 1956).

Compounding Ingredients for Rubber, 3rd edn., compiled by the Rubber World (New York, 1961).

B. J. WILSON (on behalf of the Rubber and Plastics Research Association of Great Britain), *British Compounding Ingredients for Rubber*, 2nd edn. (Heffer, Cambridge, 1964).

P. KLUCKOW (trans. D. KERRY), *Rubber and Plastics Testing* (Chapman & Hall, London, 1963).

Journals

Transactions and Proceedings of the Institution of the Rubber Industry.

Rubber and Plastics Age (monthly), Rubber and Technical Press Ltd., 25 Lloyd Baker St., London, WC 1—an international journal—summaries in French, German, and Russian.

Rubber Journal (monthly), the MacLaren Group, PO Box 109, Davis House, 69 High St., Croydon.

Rubber World, Bill Brothers, 630 Third Ave., New York.

Rubber—Rapra Abstracts (monthly), Rubber and Plastics Research Association of Great Britain.

Trade Associations

British Cellular Rubber and Plastics Manufacturers' Association, 236 Royal Exchange, Manchester.

British Latex Foam Manufacturers' Association, 236 Royal Exchange, Manchester.

British Rubber Manufacturers' Association, 236 Royal Exchange, Manchester.

British Seamless Rubber and Plastics Manufacturers' Association, 236 Royal Exchange, Manchester.

Federation of British Rubber and Allied Manufacturers, 9 Whitehall, London, SW 1. Publishes *Directory of the British Rubber Industry.*

Rubber Manufacturing Employers' Association, 236 Royal Exchange, Manchester.

Rubber Proofers' Association, 12 York St., Manchester.

Rubber and Plastics Manufacturers' Association, Speke Hall Ave., Speke, Liverpool.

Professional Body

Institution of the Rubber Industry, 4 Kensington Palace Gardens, London, W 8. Publishes *Transactions*.

Research Association

Rubber and Plastics Research Association of Great Britain. Shawbury, Shrewsbury, Shropshire. Publishes *Rubber Abstracts* and *Bulletins*.

S25 Silicones

The silicones are synthetic materials based on silicon and may be produced in the form of liquids, greases, resins, or elastomers. Their outstanding properties are thermal stability, good dielectric properties and little change in viscosity with temperature. They find many applications ranging from special lubricants and polishes, silicone rubbers for gaskets and flexible insulations; heat resistant resins used for insulating wires, impregnating glass cloth, and making heat resistant paints; glass, paper, cotton may be made water-repellant by silicone treatment.

Books

E. G. Rochow, *An Introduction to the Chemistry of the Silicones*, 2nd edn. (Wiley, New York, 1951).

R. R. McGregor, *Silicones and their Uses* (McGraw-Hill, New York, 1954).

H. W. Post, *Silicones and other Organic Silicon Compounds* (Reinhold, New York, 1949).

E. G. Rochow, D. T. Hurd, and R. N. Lewis, *Chemistry of Organo–Metallic Compounds* (Wiley, New York, 1957).

R. N. Meals and F. M. Lewis, *Silicones* (Reinhold, New York, 1959).

This is one of a series of books published by Reinhold each giving guidance in application—readers may be interested in the other titles:

W. PAIST, *Cellulosics.*
I. SKEIST, *Epoxy Resins.*
M. A. RUDNER, *Fluorocarbons.*
M. S. THOMPSON, *Gum Plastics.*
D. J. DUFFIN, *Laminated Plastics.*
R. L. BUTZKO, *Plastic Sheet Forming.*
D. E. FLOYD, *Polyamide Resins.*
T. O. J. KRESSER, *Polyethylene.*
B. A. DOMBROW, *Polyurethanes.*
W. M. SMITH, *Vinyl Resins.*

Also *Acrylic Resins*, *Amino Resins*, *Polystyrene*, *Polyesters* and *Phenolic Resins.*

J. H. HARWOOD, *Industrial Applications of the Organo–Metallic Compounds* (Chapman & Hall, London, 1963).

Journals and organizations are not confined to silicones alone, but those mentioned under S21, Plastics, will apply.

S26 Soaps

Soap is manufactured in all parts of the world, and the largest manufacturers are interested also in the manufacture of modern detergents.

Books

Blue Book of the Soap and Chemical Specialities, official year book of the Chemical Specialities Manufacturers' Association.

Year Book of Soap, Perfumery and Cosmetics (United Trade Press, London).

Chemical Manufacturers' and Soap Makers' Directory (Franey, London).

J. DAVIDSON, E. J. BETTER, and A. DAVIDSOHN, *Soap Manufacture* (Interscience, New York, 1953).

G. MARTIN, *The Modern Soap and Detergent Industry*, 3rd edn. (Technical Press, London, 1950).

Journals

Soap and Chemical Specialities (monthly), the Chemical Specialities Manufacturers' Association.

Soap, Perfumery and Cosmetics (monthly), United Trade Press, 9 Gough Sq., Fleet St., London, EC 4.

Trade Associations

Soap, Candle, and Edible Fat Trades Employers' Federation, 2 Kingscote St., London, EC 4.

Soap Makers' Association, 6 Holborn Viaduct, London, EC 1.

Society of British Soap Makers, c/o Carter, Son & White, 16 Northumberland Ave., London, WC 2.

S27 Solvents

The chief industrial solvents are organic liquids used in the extraction industries as rubber, lacquer, and paint solvents, and for a great variety of other uses. The solvent frequently serves the useful purpose of bringing a solid into a fluid state.

Journals and organizations dealing with solvents are to be found in the using industries, and references of interest will be found under S5, Perfumes; S16, Paints; S21, Plastics; S22, Plasticizers, and others.

Books

A. K. DOOLITTLE (of Union Carbide Carbon Corporation), *The Technology of Solvents and Plasticizers* (Wiley, New York, 1954).

I. MELLAN, *Industrial Solvents*, 2nd edn. (Reinhold, New York, 1950).

T. H. DURRANS, *Solvents*, 7th edn. (Chapman & Hall, London, 1957).

I. MELLAN, *Source Book of Industrial Solvents*, 3 vols. (Reinhold, New York, 1957–9). Vol. 1 was called *Handbook of Solvents* but later volumes changed their name to avoid confusion with another book.

L. SCHEFLEN and M. B. JACOBS, *The Handbook of Solvents* (Van Nostrand, New York, 1953). Section II contains physical constants of over 2700 solvents.

S28 Resins

This section refers, of course, to synthetic resins. Originally the term "resin" was used for certain sticky substances exuded from certain trees, but now it is extended to include "synthetic" resins some of which have different properties. All of them have one property in common—at some stage of their existence they are plastic.

The difference between resins and plastics is vague, and many of the later synthetics may be called either resin or plastic. Originally those synthetics were called "resins" which were used as substitutes for the natural resins normally in a coating composition, whereas the term "plastic" was used where the products were moulded or extruded.

The literature and organizations of this section therefore are also covered by the sections under S21, Plastics, or S16, Paints, but the following specialist books are worth noting:

C. ELLIS, *Chemistry of Synthetic Resins*, 2 vols. (Reinhold, New York, 1935).

B. GOLDING, *Polymers and Resins* (Van Nostrand, New York, 1959).

R. S. MORRELL (Ed.), *Synthetic Resins and Allied Plastics*, 3rd edn. (OUP ,London, 1951).

S29 Synthetic Rubber

The Journals and Organizations listed under S24, Rubber Chemicals, are mostly relevant here and should be consulted. The following books specialize in the synthetic product:

G. S. WHITBY (Ed.), *Synthetic Rubber* (Wiley, New York, 1954). Prepared under the auspices of the Division of Rubber Chemistry of the American Chemical Society.

D. W. HUKE, *Introduction to Natural and Synthetic Rubbers* (Hutchinsons, London, 1961).

H. BARRON, *Modern Synthetic Rubbers* (Chapman & Hall, London, 1949).

W. J. NAUNTON, *Synthetic Rubber* (Macmillan, London, 1937). A simple introduction to the position at that time. It is interesting also to note Chapter 9, "Future Outlook", in the light of today's developments.

H. J. STERN, *Rubber, Natural and Synthetic*, 2nd edn. (Maclaren, London, 1967).

S30 Tanning and Leather Materials

Books

The Leather Directory (annually) (Benn Bros., London—in association with the British Leather Federation).

G. D. MCLAUGHLIN and E. R. THEIS, *The Chemistry of Leather Manufacture* (Reinhold, New York, 1945).

D. WOODROFFE (Ed.), *Standard Handbook of Industrial Leathers* (National Trade Press, London, 1949).

J. A. WILSON, *Modern Practice in Leather Manufacture* (Reinhold, New York, 1941).

Principles and Processes of Light Leather Manufacture (Chemical Publishing Co., New York, 1942).

F. O'FLAHERTY, W. T. RODDY, and R. M. LOLLAR (Eds.), *The Chemistry and Technology of Leather*, 3 vols. (Reinhold, New York, 1956–62).

J. H. SHARPHOUSE, *The Leather Workers' Handbook* (Leather Producers' Association for England, Scotland, and Wales, 9 St. Thomas St., London, SE 1, 1963). For new entrants—based on the syllabus of the City and Guilds examinations.

Journals

Leather (weekly), Benn Bros., Bouverie House, 154–60 Fleet St., London, EC 4.

Leather Goods (monthly), Benn Bros., London.

Trade Associations

British Kid Tanners' Association, 9 St. Thomas St., London, SE 1.

Master Tanners' Association, 80–6 Lord St., Liverpool, 2.

North West Tanners' Federation, 80–6 Lord St., Liverpool, 2.

Oak Bark Tanners' Association, 52 Lincolns Inn Fields, London, WC 2.

British Tanning Extract Manufacturers' Association, 52 Lincolns Inn Fields, London, WC 2.

British Leather Federation, 9 St. Thomas St., London, SE 1.

Professional Bodies

Society of Leather Trades Chemists, 52 Crouch Hall Lane, Redbourn, Herts. Publishes monthly *Journal.*

The Leather Institute, Leather Trade House, 9 St. Thomas St., London, SE 1.

Research Association

British Leather Manufacturers' Research Association, Melton Park, Egham, Surrey. Publishes monthly *Journal.*

S31 Textile and Dyeing Auxiliaries

The Textile Industry is generally regarded as standing in its own right outside the chemical industries but it is, of course, one of the

largest users of chemicals as auxiliaries in the processes of dyeing and finishing. The early Chemical Industry owed much to the demands of the textile mills pressing for larger quantities of chemicals and for newer products.

Those in the Chemical Industry who deal with textile auxiliaries for dyeing and finishing should, of course, familiarize themselves with the textile processes involved and with the structure of the industry, which is complex. For this reason references to textile journals and organizations are included here.

Books

H. W. SCHMIDLIN, *Preparation and Dyeing of Synthetic Fibres* (Chapman & Hall, London, 1963).

E. R. TROTMAN, *Dyeing and Technology of Textile Fibres*, 3rd edn. (Griffin, London, 1964).

See also the books on dyeing listed in S4, Dyestuffs.

Journals

American Dyestuff Reporter (fortnightly), official journal of the American Association of Textile Chemists and Colorists.

Man-made Textiles (monthly), an international journal, Old Colony House, South King St., Manchester, 2.

Melliand Textilberichte (monthly), also international, Rohrbacher St., Heidelberg.

Modern Textiles (formerly *Rayon and Synthetic Textiles*) (monthly), Rayon Publishing Corp., 303 Fifth Ave., New York.

Trade Associations

United Kingdom Textile Manufacturers' Association, Midland Bank House, Cross St., Manchester, 2.

Textile Finishing Trades Association, 16 St. Mary's Parsonage, Manchester, 3.

Dyers' and Finishers' Association, Commerce House, Cheapside, Bradford.

Federation of Piece Dyers and Finishers, Midland Bank Buildings, Spring Gardens, Manchester, 2.

Employers' Federation of Dyers and Finishers, Midland Bank Buildings, Spring Gardens, Manchester, 2.

Midland Hosiery Dyers' and Finishers' Federation, c/o M. Dodson Esq., Charnwood Chambers, Market Place, Loughborough.

Professional Bodies

Textile Institute, 10 Blackfriars St., Manchester, 3. Publishes monthly *Journal*, *Transactions*, *Year Book*. Grants qualifications by examination.

Society of Dyers and Colourists, 19 Piccadilly, Bradford, 1. Publishes monthly *Journal*—sponsors *The Colour Index* (Fig. 11) (see page 98). Sets certain standard tests for industry and grants qualifications.

Research Associations

The Research Associations named under S4, Dyestuffs, are relevant also to this field (see page 100).

S32 Veterinary Preparations

Books

J. M. Kays, *Basic Animal Husbandry* (Prentice-Hall, New York, 1958).

W. C. Miller and E. D. S. Robertson, *Practical Animal Husbandry*, 7th edn. (Oliver & Boyd, Edinburgh, 1959).

G. F. Boddie, *Introduction to Veterinary Therapeutics* (Oliver & Boyd, Edinburgh, 1952).

G. N. Henderson and J. Stratton (Eds.), *Baillière's Veterinary Handbook*, an important work of reference (Baillière, Tindall & Cox, London, 1963).

Sir T. Dalling (Ed.), *International Encyclopedia of Veterinary Medicine*, 5 vols. (Green, Edinburgh, 1966).

Journals

British Veterinary Journal (monthly), Baillière, Tindall & Cox, London).

W. A. Poole (Ed.), *The Veterinary Annual* (latest 1964–5) (John Wright, Bristol, 1965). With good literature survey.

The Veterinary Bulletin (monthly), Commonwealth Bureau of Animal Health, Weybridge.

Trade Association

Associated Manufacturers of Veterinary and Agricultural Products, Alembic House, 93 Albert Embankment, London, SE 1.

Professional Bodies

Animal Health Trust, 14 Ashley Place, London, SW 1. This is an animal health centre.

British Veterinary Association, 7 Mansfield St., London, W 1. Publishes *Veterinary Record* (weekly) and *Research in Veterinary Science* (quarterly). Is also an Animal Health Centre.

Royal College of Veterinary Surgeons, 32 Belgrave Sq., London, SW 1. Publishes *Register* (annually).

Research Association

Animal Diseases Research Association, Moredun Institute, Gilmerton, Edinburgh, 9.

S33 Water-treatment Chemicals

The problem of water supply has now assumed world importance. Concentrations of population make enormous demands, and these can only be met in some cases by the treatment of sea-water and estuary water to provide potable water. In these

processes chemical treatments are frequently required to minimize scale formation, and water-treatment chemicals are in great demand.

Books

E. NORDELL, *Water Treatment*, 2nd edn. (Reinhold, New York, 1961), comprehensive.

G. F. MUGELE and A. WISEMAN, *Water Treatment* (Newnes, London, 1958), a short survey.

G. V. JAMES, *Water Treatment*, 3rd edn. (Technical Press, London, 1965).

A. C. TWORT, *A Text-book of Water Supply* (Arnold, London, 1963).

Journals

Journal of the Institution of Water Engineers (8 per year), 11 Pall Mall, London, SW 1.

Water and Water Engineering (monthly), Colliery Guardian Co., Ltd., 30 Furnival St., London, EC 4.

Trade Association

Water Purification Plant Group, c/o Peat, Marwick, Mitchell & Co., Glen House, Stag Place, London, SW 1.

Professional Body

Society for Water Treatment and Examination, 41 Carshalton Rd., Sutton, Surrey. Publishes quarterly *Proceedings*.

Research Association

Water Research Association, Ferry Lane, Marlow, Bucks.

CHAPTER 7

Patents

Why Patents are Important

A patent (Fig. 12) is essentially an agreement between the state and an inventor in which the inventor is allowed monopoly rights for 16 years in Great Britain, for his invention in return for making a full disclosure about it to the public. A British patent may cover a machine, a process, or something to be manufactured, whilst in the United States, a botanical plant can also be patented. A brief but informative general account of patents is given in *How to Find*

BAKER.
16th Feb. 1618.

7. A spiall priviledge graunted at the miaan of Sir GEORGE STAY, knight, to ABRAHAM BAKER & his ass^{ns}, for 31 yeares next, of the sole making, working, & compounding (wthin this realm) of a c̃teine stuffe called smault, and to sell the same to anie paynters or others at reasonable rates, wth power to the patentee and all others to import saffer & pottashes or anie other stuffe fit for the making thereof—paying His Ma^{ts} customes and also paying yearelie into His Ma^{ts} exchequer xx^{li}. Teste apud Westm^{r}, xvj die Februarij p̃d.
p bře de privato sigillo.

FIG. 12. The first British Chemical Patent, dated 1618.
(By permission of HMSO.)

Out in Chemistry by C. R. Burman (Pergamon, 1965). An excellent and more comprehensive treatment of the subject is to be found in F. Newby, *How to Find Out about Patents* (Pergamon, Oxford, 1967). This contains many illustrations, examples, and references to journals in the field of patents.

Patents serve as a source of published technical information and have great value as a current awareness tool. They are often a method of finding out about developments which have not been

previously, and may never be, published elsewhere. They are therefore read like papers in the scientific and technical journals. In addition, patents often indicate the direction in which a company is moving before anything else does because they are published well in advance of production commencing.

Probably the most important single use of existing patents in the Chemical Industry is in retrospective searching in order to avoid wasting time and money on research which has already been carried out, and the results published. Sometimes quite a good idea of the history of a whole branch of chemistry can be gleaned entirely from the patents published on it.

Provisional Patents

A provisional patent costs £8 8*s*. and is simply a record of a claim by an inventor which is dated on receipt at the Patent Office and filed without being examined. It enables an inventor to obtain protection for a year from that date during which time he can develop his invention and draw up a complete specification. A provisional patent is abandoned by the Patent Office after 15 months and from that time someone else could patent the same invention if the original inventor had not previously had a complete specification and obtained letters patent for it during the one year of life of the provisional patent.

As provisional patents are never published it is not possible to find out anything about them. Their main use is in establishing a date in case of dispute and this protection extends to all the countries which are signatories to the International Patents Convention. These countries include: the United States, the USSR, Japan, countries of the British Commonwealth, and most countries of Europe.

General Sources of Information about Patents

Many firms, research associations, development associations, etc., have their own patent indexes arranged (a) by subject, (b) by patentee.

The subject index can be used to find the name of the patentee and the patent number and hence to obtain a general impression of recent work. It will also show who (or which companies) have been carrying out research in particular chemicals and for what purpose these materials are useful. In addition this index reveals much of the chemistry of a specific compound.

The patentee index firstly enables a patent number to be found. Secondly, it enables one to find out whether the corresponding patents have been taken out in other countries, and also it enables one to see what research someone has been carrying out.

A good annual review of patent law and procedure in Britain and the other principal patenting countries of the world is given in *Derwent Patents Manual* (Derwent Publications Ltd., Rochdale House, 128 Theobalds Rd., London, WC 1).

Publications of the British Patent Office

There are 279 classes into which the subject matter of all British patents is classified; for details the *Classification Key* (Patent Office, London) should be consulted. A *Reference Index to the Classification Key* is also published by HMSO for the Patent Office. This is divided into 3 sections as follows:

1. Alphabetical list of catchwords and subdivisions giving the respective class number of each.
2. The classes arranged numerically with details of their contents.
3. A table showing the 44 groups to which the classes have been assigned.

Abridgments of Specifications (HMSO) is divided into volumes, each of which contain 20,000 patents in one group. Each volume contains (1) a subject index, which lists the numbers of the patents in it, and (2) a name index. A *Group Allotment Index* (HMSO) is published after each 20,000 specifications have been issued and this lists patents showing the group in which each abridgment has been published. Also for each 20,000 specifications an *Index to Names of Applicants* (HMSO) is published.

The *Official Journal* (*Patents*) (HMSO) is published every Wednesday and gives:

1. A list of current patents and dates when they can be inspected.
2. Details of patents which have been amended, abandoned, or become void.
3. A subject index and a group allotment index of complete specifications accepted.
4. Details of recent additions to the Patent Office library.

Libraries

Complete information on British patents including abridgments, specifications, the *Official Journal* (*Patents*), and indexes is held at the National Reference Library of Science and Invention, (formerly the Patent Office Library) and at the repository libraries, including many public libraries. The Patent Office, 25 Southampton Buildings, Chancery Lane, London, WC 2, also collects most foreign patents and these are available for inspection by the public.

The Main Patent Abstract Journals

In order to trace patents of interest to the Chemical Industry the following two most important chemical abstract journals in the world should be referred to:

1. *American Chemical Society Abstracts* (twice a month), American Chemical Society, Easton, Pa. This is often known as *Chemical Abstracts* and it contains summaries of patent specifications and numerical patent indexes of some twenty of the world's principal patenting countries. The formula indexes are outstandingly useful at the beginning of a search on a specific compound because they help the nomenclature to be found and this in turn leads to the entry in the subject index.

2. *Chemisches Zentralblatt* (weekly), Akademie Verlag, Berlin, W 8. This journal covers similar ground to *Chemical Abstracts* but with the addition of the Patentrückzitate which lists many of the corresponding patent specifications for different countries. The use of *Chemisches Zentralblatt* is facilitated by reference to the book entitled *Chemisches Zentralblatt: das System.*

Derwent Publications

In addition to the above two chemical abstract journals, Derwent Publications Ltd., Rochdale House, Theobalds Rd., London, WC 1 (Tel. Chancery 5851), publish the following, which are of very considerable importance to the Chemical Industry:

Complete Coverage—Weekly	*Chemical Groups Only—Weekly*
British Patents Abstracts	*Belgian Patents Report*
German Patents Abstracts	*French Patents Abstracts*
Soviet Inventions Illustrated	*Japanese Patents Report*

The Derwent patents journals which follow are also issued weekly and give detailed abstracts in English and have subject and name indexes for *all* British, German, French, Indian, and South African patent specifications issued within the last 3–4 weeks:

Petrochemicals
Fine Chemicals
Plastics (this includes chemical engineering patents and Belgian patents).

Derwent also publish more specialized monthly bulletins which give abstracts in English of all recent British, German, French, Indian, and South African patents with the following titles:

Polychemical Patents Bulletin
Chemical Process Patents Bulletin
Pharmaceutical Patents Bulletin
Organic Patents Bulletin
Paints and Resins Patents Bulletin.

Uses of Patent Abstract Journals

Abstract journals have four well-defined uses, as follows:

1. To get a summary of a patent specification.
2. To trace the historical development of specific work.
3. To help in tracing corresponding patents for different countries.
4. To help in determining whether or not a compound has been described in the literature previously.

Reference Works and Textbooks

Reference works and textbooks are used as follows:

1. To get details of older patents relating to specific compounds or processes.
2. To help in deciding whether or not a specific compound or process has been previously mentioned in the patent literature.

Amongst many which could be mentioned, the following is a representative selection of reference works:

A. *Beilsteins Handbuch der Organischen Chemie* (Springer, W. Germany). This is undoubtedly the most comprehensive reference work on organic chemistry and forms a compilation from the scientific and patent literature of data on all organic compounds systematically arranged according to their structural formulas. In order to understand the system of classification used in Beilstein, a guide such as one of the following should be consulted:

   Mellon's *Chemical Publications* (McGraw-Hill, New York, 1958) or

   Bottle's *Use of the Chemical Literature* (Butterworths, London, 1962).

B. *Merck Index of Chemicals and Drugs*, 7th edn. (Merck, Rahway, NJ, 1960) (Fig. 6).

C. *Elsevier's Encyclopaedia of Organic Chemistry* (Elsevier, Amsterdam, 1940).

D. *Thorpe's Dictionary of Applied Chemistry*, 4th edn. (Longmans, Green, London, 1937–56) (Fig. 3).

E. Kirk and Othmer's *Encyclopedia of Chemical Technology*, 2nd edn. (Interscience, New York, 1963) (Fig. 5).

Special Countries

Belgium is specially important because although the complete specification is *not* examined by the Belgian Patent Office the complete specification is open to public inspection between 3 and 6 months after filing it. This means that although the matter may in fact not be novel, these specifications are of great value because they are often the earliest disclosure of an invention. However, printed specifications are not available until some 2 or 3 years after the date of filing.

French specifications also are not examined for novelty; they are open to public inspection between 9 and 13 months from the date of filing and printed copies are available about 3 months later.

By comparison in Britain it takes 2 or 2½ years from the date of filing to being open for public inspection when printed copies are available. There is a novelty examination.

Thus, from the point of view of current awareness, wide use is made of Belgian and French patents. However, those countries' specifications which have been examined are more likely to be technically sound and their novelty more certain, but they take longer to produce.

CHAPTER 8

Research

RESEARCH can be defined as "the systematic search for new facts by the scientific study of the subject!" Non-scientists sometimes confuse research with testing and analysis because all of them are normally carried out in a laboratory. However, chemical testing is more concerned with the examination of the properties of a material, for example in order to determine how much impurity is present, whilst analysis is concerned with the constituents of a material.

Before any practical research work is even planned a literature survey is carried out in order to (1) avoid duplicating work already undertaken and (2) find out what similar work has been done and with what results. This provides the best starting point for deciding along which lines the research is to be carried out. This survey is often carried out by an information scientist (for details see Chapter 2).

The literature survey, therefore, precedes any practical work and the following are the main types of publications which are likely to be used together with other works which may be utilized as the research proceeds. It was suggested by P. W. Soden of the Department of Mechanical Engineering of the University of Manchester Institute of Science and Technology as an outline of the various types of published material to be consulted during the literature study.

(1) *Books*

(a) Textbooks.

(b) Handbooks, e.g. J. H. Perry, *Chemical Engineers' Handbook*, 4th edn. (McGraw-Hill, New York, 1963) (Fig. 13).

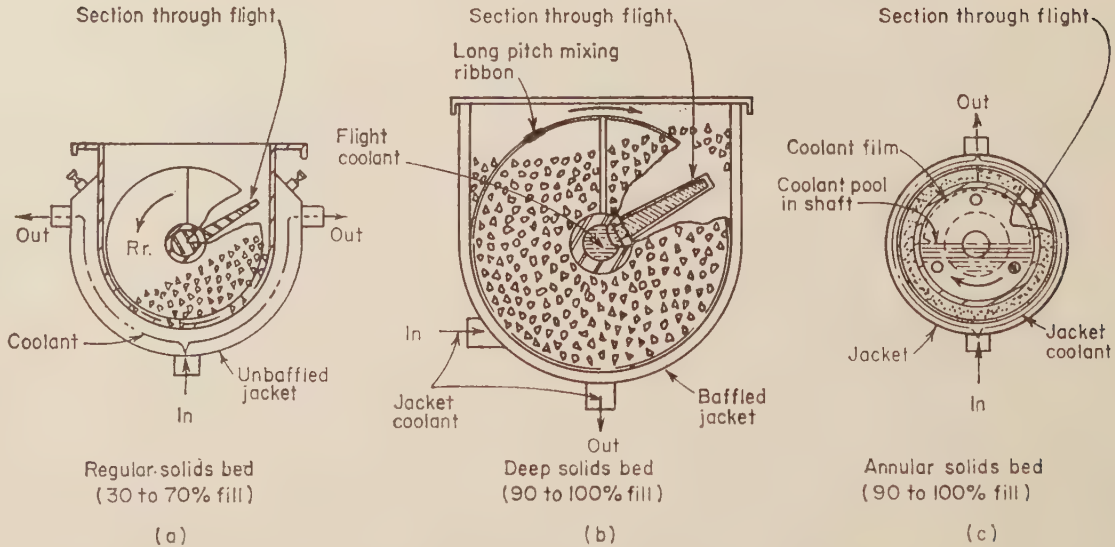


FIG. 11-40. Spiral-conveyor adaptations as heat-transfer equipment. (*a*) Standard jacketed solid flight. (*Courtesy of The Jeffrey Mfg. Co.*) (*b*) Large spiral, hollow flight. (*Courtesy of Reitz Mfg. Co.*) (*c*) Small spiral, large shaft. (*Courtesy of Fuller Co.*)

comparted into four lesser areas with ducts between. Hot gases are drawn through the ducts en route from the outer oven to the stack to provide about 75 per cent more heating surface, improving efficiency and capacity with a

Conveyor-belt Devices. The *metal-belt* type (Fig. 11-37*a*) is the only device in this classification of material-handling equipment that has had serious adaptative effort expended on it for *indirect heat-transfer* service with

FIG. 13. *Chemical Engineers' Handbook* (4th edn.), Perry, Chilton, and Kirkpatrick. (By permission of McGraw-Hill, Inc.)

$$\frac{k_g a.Z}{G} = 1{\cdot}5$$

From the slope of DF, $\frac{W}{G} = \frac{33{\cdot}3}{45}$

so that $G = \frac{4{,}000 \times 10 \times 45}{33{\cdot}3} = 54{,}100$ lb. air/hour.

Then, as $k_g a$ for this packing $= 1{,}720$

$$Z = \frac{1{\cdot}5 \times 54{,}100}{1{,}720} = 47{\cdot}2 \text{ ft. of packing.}$$

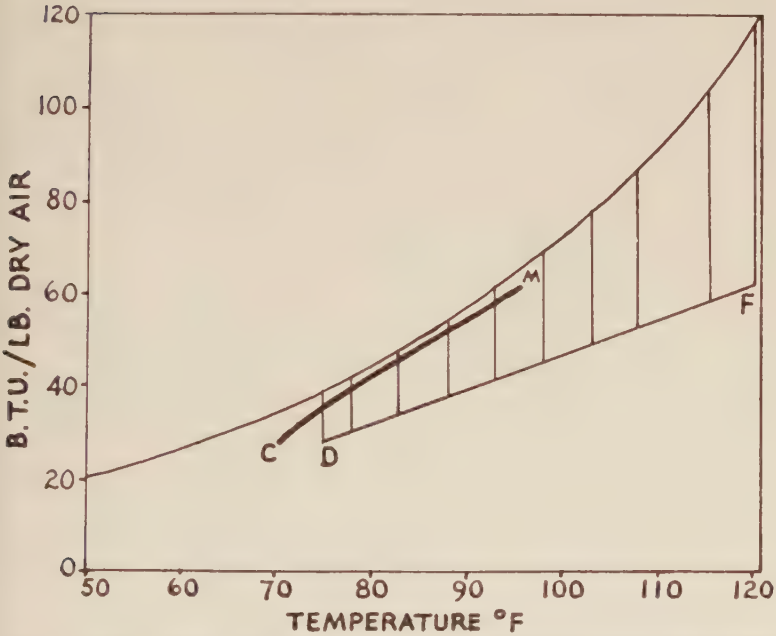


FIG. 8.—THE DIAGRAM FOR THE APPLICATION OF THE RESULTS TO THE DESIGN OF A COOLING TOWER.

CROSS-SECTION OF TOWER. In order to maintain the certainty of control of $k_g a$, an air velocity equivalent to that of the experimental tower should be provided.

In the experiment

$$\text{air rate} = \frac{5{,}540}{3 \times 3} = 615 \text{ lb./sq. ft./hour.}$$

Thus, the cross-section of the large cooler must be

$$\frac{54{,}100}{615} = 88 \text{ sq. ft.}$$

FIG. 14. *Chemical Engineering Data Book*, Ross and Freshwater. (By permission of Leonard Hill Books.)

(c) Data books, e.g. *International Critical Tables* (McGraw-Hill, New York, 1926–33) and J. K. Ross and D. C. Freshwater, *Chemical Engineering Data Book*, 24th edn. (Leonard Hill, London, 1962) (Fig. 14).

(d) Encyclopaedias

(1) General, e.g. *The Encyclopaedia Britannica or Scientific Encyclopaedia*, 3rd edn. (Van Nostrand, New York, 1958).

(2) Subject, e.g. *Faraday's Encyclopaedia of Hydrocarbon Compounds* (Butterworth's, London).

(e) Dictionaries

(1) General, e.g. *The Concise Oxford Dictionary* (Clarendon Press, Oxford) or *Technical Dictionary* (Chambers, London, 1964).

(2) Subject, e.g. *Condensed Chemical Dictionary*, 6th edn. (Reinhold, New York, 1961).

(3) Translating, e.g. *Standard German and English Dictionary* (Harrap, London).

(4) Technical Translating, e.g. Z. Sobecka, *Dictionary of Chemistry and Chemical Technology, in Six Languages* (English, French, German, Polish, Russian, and Spanish (Pergamon, Oxford) (Fig. 8).

(2) *Periodicals*

(a) Sources

(1) Professional institutions' proceedings (technical papers) and journals.

(2) Commercial publishers.

(3) House journals.

(4) Universities, colleges, research associations, etc.

(b) Scope

(1) General scientific.

(2) General subject.

(3) Specific. These would include important foreign publications, cover-to-cover translations, and indexing and abstracting serials.

(3) *Research Reports*

(a) Sources.

(1) University theses and dissertations.

(2) Government research establishments, e.g. National Physical Laboratory (which, since 1966, includes the work of the former National Chemical Laboratory).

(3) Industrial organizations, e.g. Coal Tar Research Association or large companies, e.g. ICI.

(4) *Conferences*

(a) Regular, e.g. *Annual Reports on the Progress of Chemistry* (Chemical Society, London).

(b) Irregular, e.g. chemical uses of radio-isotopes.

(5) *Review Serials*

Many titles can be found in *Bibliography of Reviews of Chemistry*.

(6) *Standards and Codes of Practice*

(a) Standards

1. Calculation procedures.
2. Experimental procedures.
3. Material and test specifications, e.g. British Standards Institute specifications.

(b) Codes of practice, e.g. American Society for Testing Materials, *Boiler and Pressure Vessel Code*.

(7) *Government Publications*

(a) Committee reports.

(b) Miscellaneous data.

(8) *Directories*

(a) People, e.g. *Directory of British Scientists* (Benn Bros., London, annually).
(b) Societies and institutions, e.g. *Scientific and Learned Societies of Great Britain*, 61st edn. (Allen & Unwin, London, 1964).
(c) Equipment and materials, e.g. *Scientific Instrument Directory* (United Science, London, annually).

Although most of the research carried out for the Chemical Industry is actually done by firms themselves, this is by no means always the case. Firms also have research done for them by:

1. Consultants and sponsored research organizations.
2. Research associations and government research stations.
3. Universities and colleges.
4. Development associations.

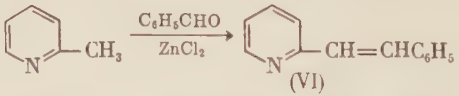
Research in the Chemical Industry

Once the decision has been taken to undertake research on a particular subject, the research team must be chosen. This usually comprises a project leader who holds a research degree, i.e. a M.Sc. or Ph.D. degree, and who therefore has been trained in research methods. To assist him, he may have two or more research assistants. These may have ordinary national certificate, higher national certificate, or first degree or equivalent qualification. The project leader supervises his assistants and interprets the results which they present to him. He then decides what will be the next line of action for his team.

There are several ways by which it can be found out in what research a firm is engaged. Probably the simplest is to ask directly and this method is most likely to succeed only if it is clear that the information will not be used in any way that might help a competitor. Advertisements for research staff often disclose the nature of the work to be undertaken in general terms.

ily with Brönsted and Lewis acids. The pyridine system is aromatic. It is stable to heat, to acid, and to alkali. It undergoes substitution, with the 3-position favored in sulfonation and nitration. It shows resonance energies of 21–31 kcal/mole. Pyridine is used as a solvent for organic and inorganic compounds, as an acid binder, as a basic catalyst, and as a reaction intermediate.

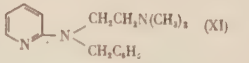
Oxidation of pyridine homologs by nitric acid or by permanganate converts the substituent group in a preparative manner to a carboxylic acid. Reaction at the methyl group of 2- and 4-methylpyridine tends to occur more readily than at the methyl group of 3-methylpyridine. Thus, 2- and 4-methylpyridine condense with benzaldehyde to give styryl derivatives (VI), whereas 3-methylpyridine does



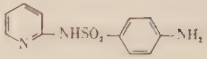
(VI)

not react. With butyllithium or sodium amide, 2- and 4-methylpyridines metalate to give pyridylmethyl metals (VII), which react normally with stituent. Bromopyridines form Grignard and lithium derivatives that react normally.

3-Nitropyridine, from nitration of pyridine, can be converted to 3-aminopyrimidine. 4-Nitropyridine-*N*-oxide (IX) with iron and acetic acid gives 4-aminopyridine. 2-Aminopyridine, prepared on an industrial scale by direct amination of pyridine with sodamide, is utilized in the manufacture of the antihistaminic, Pyribenzamine (XI), and the bacteriostatic agent, sulfapyridine (XII).



(XI)



(XII)

In most of its reactions, 3-hydroxypyridine behaves as a normal phenol, just as 3-aminopyridine behaves as a normal aromatic amine. However, hydroxy or amino groups at the pyridine 2 or 4 positions show some reactions that are not characteristic of phenols or aromatic amines. Hydroxyl or amino groups on any pyridine position make electrophilic substitution easier and, as ortho-para directing groups, take control of the orientation. 2-Pyridone is prepared from 2-aminopyridine by a diazotization procedure. 3-Hydroxypyridine is produced either by sulfonation of pyridine followed by

FIG. 15. *Encyclopaedia of Science and Technology*, Vol. 11. (By permission of McGraw-Hill, Inc.)

Research Information from Libraries

Some information about research in a very limited number of firms is published in *Industrial Research in Great Britain*, 4th edn. (Harrap, London, 1962). Also *Aslib Directory* (Aslib, London, 1957, amendment list 1961) gives details of the subjects covered by firms' libraries which sometimes indicates where a firm's interests lie.

By far the most important publication in English dealing with chemical research is *American Chemical Society Abstracts* (American Chemical Society, Easton, Pa.). This is published every 2 weeks and it aims to report all new chemical information by providing abstracts of (1) scientific and technical papers, and (2) patent literature. These are taken from:

(a) Journals.
(b) Proceedings of conferences.
(c) USA university theses.
(d) USA and foreign patents.

Chemisches Zentralblatt (German Chemical Society, Akademie Verlag, Berlin) is published weekly and generally covers much the same ground as *Chemical Abstracts*, but it is more up to date with material from eastern Europe and USSR.

Patents enable a firm's changing research interests to be closely followed. One of the simplest ways of doing this is to consult the appropriate Derwent Publications Ltd. abstract (see Chapter 7), as a name index is provided.

Consultants and Sponsored Research Organizations

There are many laboratories listed in the Royal Institute of Chemistry *Directory of Consultants* where, for a fee, confidential analytical or research work will be carried out for a client. This directory is available in most public libraries or is obtainable from the Royal Institute of Chemistry, 30 Russell Sq., London, WC 1.

Most consultant laboratories specialize in certain branches of chemistry, e.g. boiler-feed water or textile finishes. Many of them

carry out routine testing for firms which do not have the necessary facilities, e.g. Manchester Chamber of Commerce Testing House, 10 Barlow Moor Rd., Manchester, 20, keeps a colony of moths for testing moth-proofing agents as applied to woollen goods.

There are a number of research organizations some of which carry out excellent research for clients, in some cases these are non-profit-making organizations. It is usual for these bodies to refuse a second commission for work similar to that already undertaken for another client. This is in order to avoid any risk of interfering with the confidential relationship established with the first client. Some of the best-known British organizations in this field are given below:

Fulmer Research Institute, Stoke Poges, Buckinghamshire.
Arthur D. Little Research Institute, Inveresk, Musselburgh, Scotland.
Sondes Place Research Institute, Dorking, Surrey.
Yarsley Research Laboratories, Clayton Rd., Chessington, Surrey.
International Research and Development Co. Ltd., Fossway, Newcastle-upon-Tyne.

Indexed information about these and other similar research organizations will be found in *Industrial Research in Britain*, 4th edn. (Harrap, London, 1962).

Research Associations

There are about fifty British co-operative research associations; each receives a grant from the Ministry of Technology (formerly the Department of Scientific and Industrial Research or DSIR). In general, the research associations operate a variety of services for their members, who all pay a subscription. In some instances non-members may in some degree make use of their facilities. For example, a member of one research association can expect help by way of references and the like from other research associations.

The research associations which follow have a considerable interest in chemistry. They have been selected because it was felt

that they may be of interest to chemists (a) as places of employment where salaries may not always equal those in industry but there is often more opportunity for long-term research with less interruption for day-to-day trouble-shooting. Thus, although strictly speaking research associations are not a part of the Chemical Industry, they are considerable employers of chemists and in many cases they are situated in very pleasant surroundings. Applications for employment should be sent to the Director of Research; and (b) as sources of chemical information in their own and allied fields. Inquiries should be sent to the information officer. There is a useful brochure, *Careers in the Industrial Research Associations*, available from the Committee of Directors of Research Associations, 24 Buckingham Gate, London, SW 1.

Research Association	Address	Main Interest to Chemists
Aslib	3 Belgrave Sq., London, SW 1 (Tel. Belgravia 5050)	*Index of Unpublished Translations. Index of Theses accepted for Higher Degrees in the Universities of Gt. Britain and Ireland. Aslib Directory*—this lists all special libraries in the United Kingdom and is well indexed by subjects
Flour milling and Baking Research Association	Chorley Wood, Herts. (Tel. Chorley Wood 4111)	Bread, biscuit and flour chemistry; microbiology, biochemistry of wheat and oat grains; flour and nutrition
British Cast-Iron Research Association	Bordesley Hall, Alvechurch, Birmingham (Tel. Redditch 2715)	Metallurgy of cast-iron; moulding materials; air pollution
British Ceramic Research Association	Queens Rd., Penkull, Stoke-on-Trent (Tel. Stoke-on-Trent 44045)	Refractories, heavy clay products, high-temperature chemistry and physics of refractories and special ceramics

Research Association	Address	Main Interest to Chemists
Coal-Tar Research Association	Oxford Rd., Gomersall, Leeds (Tel. Cleckheaton 4251)	Chemistry of coal tar and its fractions; distillation, conversion of refined products to new materials
British Coal Utilization Research Association	Randalls Rd., Leatherhead, Surrey (Tel. Leatherhead 4411)	Fuel and non-fuel uses of coal
British Coke Research Association	Chesterfield, Derbyshire (Tel. Chesterfield 7171)	Metallurgical coke; carbonization, air and water pollution; analysis and testing
Cotton, Silk, and Man-Made Fibres Research Association	Shirley Institute, Manchester, 20 (Tel. Didsbury 8811)	Cotton, silk, and man-made fibres chemistry, and bleaching, dyeing, and finishing
Electrical Research Association	Cleeve Rd., Leatherhead, Surrey (Tel. Leatherhead 4151)	Insulating, magnetic, and structural materials for electrical equipment
British Food Manufacturing Industries Research Association	Randalls Rd., Leatherhead, Surrey (Tel. Leatherhead 4124)	Biochemistry, microbiology, food technology
Fruit and Vegetable Canning and Quick Freezing Research Association	Chipping Campden, Gloucestershire (Tel. Campden 319 and 479)	Manufacturing processes, microbiology, improved containers
Gelatine and Glue Research Association	Warwick St., Birmingham, 12 (Tel. Victoria 3710)	Chemistry and physics of gelatine and glue; new chemical derivatives
British Glass Industry Research Association	Northumberland Rd., Sheffield, 10 (Tel. Sheffield 66001)	Materials used in making glass, new glasses
British Industrial Biological Research Association	Woodmansterne Rd., Carshalton, Surrey (Tel. Melville 4411)	Toxicology of food additives, packaging materials, cosmetics, toilet preparations; extrapolation of animal feeding tests to humans
Commonwealth Mycological Institute	Ferry Lane, Kew, Surrey (Tel. Richmond 4086)	Industrial fungi and their best use in processes

Research Association	Address	Main Interest to Chemists
British Iron and Steel Research Association	11 Old Park Lane, London, W 1 (Tel. Grosvenor 4751)	Iron making, refining of iron into steel; slag, refractories, corrosion, fuel technology
British Jute Trade Research Association	Kinnoul Rd., Kingsway West, Dundee (Tel. Dundee 86781)	Finishing treatments, jute reinforcement for plastics
British Launderers Research Association	Hill View Gardens, Hendon, London, NW 4 (Tel. Sunnyhill 2143)	Cleaning fabrics by washing, detergency, bleaching, control of colour
British Leather Manufacturers Research Association	Milton Park, Egham, Surrey (Tel. Egham 3086)	Hides, skins, tanning, dyeing, and finishing; treatment of waste liquors
Welwyn Hall Research Association	Welwyn, Herts. (Tel. Welwyn 4771)	Chalk and whiting, manufacture and uses; powder technology
Linen Industry Research Association	Lambeg, Lisburn, Co. Antrim, N. Ireland (Tel. Lisburn 2255)	Linen technology, bleaching, dyeing and finishing
Motor Industry Research Association	Lindley, Nuneaton, Warwickshire (Tel. Nuneaton 3664)	Motor vehicles: materials of construction, fuels, lubricants, and atmospheric pollution
British Non-ferrous Metals Research Association	Euston St., London, NW 1 (Tel. Euston 6411)	Extraction, properties, fabrication, and uses of non-ferrous metals, galvanizing, electroplating, and surface finishing
Research Association of British Paint, Colour, and Varnish Manufacturers	Waldegrave Rd., Teddington, Middlesex (Tel. Teddington Lock 4427)	Paints and varnishes: raw-materials chemistry of paint and related techniques
British Paper and Board Industry Research Association	Welcomes Rd., Kenley, Surrey (Tel. Uplands 6401)	Pulping and paper making, raw materials, effluent treatment
Printing, Packaging, and Allied Trades Research Association	Randalls Rd., Leatherhead, Surrey (Tel. Leatherhead 4041)	Printing processes, paper, ink, adhesives; attack of packaging by insects and moulds

Research Association	Address	Main Interest to Chemists
Production Engineering Research Association	Melton Mowbray, Leicestershire (Tel. Melton Mowbray 4133)	Methods of production, cutting fluids, protective coatings
Rubber and Plastics Research Association of Great Britain	Shawbury, Shrewsbury, Shropshire (Tel. Shawbury 383)	Rubber and plastics: raw materials and chemistry, processing and testing
British Scientific Instrument Research Association	South Hill, Chislehurst, Kent (Tel. Imperial 5555)	Scientific and industrial instruments; help in choosing or designing the best instrument for a given job
British Steel Castings Research Association	East Bank Rd., Sheffield, 3 (Tel. Sheffield 28647)	Steelmaking, foundry processes, and moulding materials; industrial health
Timber Research and Development Association	Tylers Green, High Wycombe, Bucks. (Tel. Penn 2261)	Timber: applications, testing; laminated board and plywood; wood preservation
Water Research Association	Medmenham, Marlow, Bucks. (Tel. Hambleden 282)	Water supplies: chemical and biological analysis, chemical treatment, assessment of new pipeline materials
British Welding Research Association	Abington Hall, Abington, near Cambridge (Tel. Linton 591)	Welding processes, design of welded metal structures, pressure vessels, material selection; welds in corrosive environments
Wool Industries Research Association	Torridon, Headingly Lane, Leeds, 6 (Tel. Leeds 5-1047)	Wool utilization, processing, scouring, dyeing, and finishing; shrink-resist treatment

Government Research Stations

The government research stations which are given below are of interest to the Chemical Industry.

Most stations issue brochures describing their work and the

special facilities which they offer. They are willing to deal with relevant inquiries free of charge provided they do not take too much time.

Original work carried out at these stations is usually described in papers to learned societies and published in their proceedings. Reprints of such papers are sometimes available. Very often more practical accounts of the work and additional articles describing techniques are published in trade and technical journals. Most stations issue series of publications through HMSO, which also publishes an annual report on the work of each station. Details of these are given in *Sectional List No. 3* of HMSO publications.

Station	Address	Selected Fields of Work
Building Research Station	Garston, Watford, Herts. (Tel. Garston 4040)	All building materials; heating, lighting, and sound insulation
Forest Products Research Laboratory	Princes Risborough, Aylesbury, Bucks. (Tel. Princes Risborough 101)	Mechanical, physical, and chemical properties of timber
Institute of Geological Studies	Exhibition Rd. London, SW 7 (Tel. Kensington 9441)	Surveys and maps of rocks and minerals including coalfields, underground water sources, and mineral deposits; geophysical surveys
Joint Fire Research Organization	Borehamwood, Herts. (Tel. Elstree 1341 and 1797)	Fire: hazards, causes, and prevention of outbreaks, methods of minimizing damage to structures and danger to life; study of special hazards of industrial processes and materials
Laboratory of the Government Chemist	Cornwall House, Stamford St., London, SE 1 (Tel. Waterloo 7900)	Analytical, investigatory, and advisory services to all government departments; development of chemical and physiochemical methods of analysis

Station	Address	Selected Fields of Work
National Engineering Laboratory	East Kilbride, Glasgow (Tel. East Kilbride 20222)	Properties of materials at normal and high temperatures; fluid mechanics, fans, and low-speed aerodynamics; properties of fluids; heat transfer and heat-exchange apparatus; bearings and lubrication
National Physical Laboratory (which now includes the former National Chemical Laboratory)	Teddington, Middlesex (Tel. Teddington Lock 3222)	Chemical Standards Division: Heat capacity, reaction calorimetry, preparation of pure compounds, properties of vapours, and molecular spectroscopy Molecular Science Division: Far infrared and millimetre wave spectroscopy, electron spin resonance, polymer physics, electrochemical synthesis, high-temperature and high-pressure chemical synthesis, cryogenic techniques, and X-ray crystallography
Torry Research Station	Abbey Rd., Aberdeen (Tel. Aberdeen 24258)	Research on fish: curing, freezing, and wastage
Warren Spring Laboratory	Stevenage, Herts. (Tel. Stevenage 2080)	Research, development to pilot scale, chemical engineering, mineral science and technology, air pollution, computor control of chemical plant, the mechanics of particles and slurries; blending, mixing, cohesion and flow; heat and mass transfer

Station	Address	Selected Fields of Work
Water Pollution Research Laboratory	Elder Way, Stevenage, Herts. (Tel. Stevenage 920)	Treatment of sewage and trade wastes

Research in British Universities and Colleges

In order to locate where and by whom research on any given topic is being carried out at any British university or college (including regional technical colleges), the publication *Research In British Universities and Colleges* (HMSO London, annually) (2 vols.: *Life Sciences* and *Natural Sciences*) should be consulted. A name and subject index are included and workers and their subjects are listed under general headings covering the discipline involved. It is therefore quite a simple matter to track down any particular subject, the name of the worker, his department and college.

Those universities and colleges which have industrial liaison officers or technical information officers are listed in *Technical Services for Industry* (Ministry of Technology, HMSO, London, 1966). These men can quickly find out whether research is being carried out on any given subject in their own colleges and in addition they can arrange introductions between technical people in industry and the staff of their own colleges.

In the case of research which resulted in the writing of a thesis, this can be traced by means of *Index of Theses Accepted for Higher Degrees in the Universities of Gt. Britain and Ireland* (Aslib, London).

Research by Development Associations

Trade development associations are normally supported financially by the trade interests which they exist to foster. Some of these trade associations have research and development laboratories which carry out work of the highest quality. However, it should be borne in mind that they exist to foster and encourage the use of

their members' products. These organizations should not be confused with the co-operative industrial research associations which receive a government grant, whereas the development associations usually derive their income from a levy or subscription paid by the producers or merchants who comprise the membership of the association. Sometimes the names of these research organizations make them indistinguishable from grant-aided research associations, which is usually what is meant by the name "research association".

A few examples of research organizations of trade development associations are given below and these can be valuable sources of information in their own fields:

Natural Rubber Producers' Research Association, Welwyn Garden City, Herts.

Cement and Concrete Association Research Station, Framewood Rd., Stoke Poges, Slough, Bucks.

Tin Research Institute, Fraser Rd., Greenford, Middlesex.

Trends in Practical Research

There is a growing tendency to use instrumental methods in practical chemical research. This can be illustrated by the use of sophisticated and elegant techniques such as gas–liquid chromatography where the presence of certain chemical species are seen as peaks on a trace which has been drawn automatically. To identify the constituents by traditional methods would take far longer and would probably be less revealing.

Instruments for chemical research can be expensive and this is why some firms pay a consultant to carry out the required work. Or they may enter into a contract with a sponsored research organization or a university or college, partly in order to avoid purchasing expensive equipment and partly to avoid the difficulty of knowing what to do with the staff once the research is completed. The cost implications of this problem are dealt with later in this chapter.

Applying the Results of Research

It is becoming more widely accepted that in many countries of the world the most urgent need is not for more research but for more effort in applying the results of research which has already been carried out. To illustrate this point, suppose that somewhere there was an underdeveloped country where it was required to grow a certain difficult crop. If research had already shown precisely what conditions this crop required, the whole scheme would depend for its success upon whether or not those in control could find this out. If they did not get this information and use it, its value might be very slight. On the other hand, if it were used, how valuable it would be.

Research in Chemical Engineering

It should not be thought that chemical research is the only research in the Chemical Industry. There is a great deal of effort put into the plant in which on an industrial scale a given reaction must take place.

Firms such as ICI, Unilever, and others, find it worth investing enormous sums of money in research in chemical engineering because if it is successful it can save far larger sums.

The main government research station where an appreciable amount of research into chemical engineering is carried out is Warren Spring Laboratory, Stevenage, Herts. (Tel. Stevenage 2080). This laboratory publishes an annual progress review entitled *Chemical Engineering Research.*

Many universities and colleges carry out research into various aspects of chemical engineering and details will be found in *Research in British Universities and Colleges* (HMSO, London, annually).

Costs

Although it is difficult to generalize it now costs about £10,000 per annum to maintain a Ph.D., his assistants, equipment, and overheads in an industrial firm.

By comparison, in a university a research contract with a firm might be carried out for about £1200 per annum and in addition provide lasting and useful contacts between industry and the academics. Generally the disadvantage is that ultimately the research will have to be published, although it is sometimes possible to do this in such a way that the sponsor retains some of the essential commercial details which are not required in publishing a scientific paper. The growing number of research contracts of this type is evidence of the success and economic advantages of this arrangement.

Government-supported Research and Development

The following extract is taken, by kind permission of the Controller of Her Majesty's Stationery Office, from the Ministry of Technology publication *Technical Services for Industry* (HMSO, London, 1966):

Research and Development Contracts

The Ministry of Technology places contracts for advanced research and development or applied research with firms, research institutes, and universities. A number of such contracts are placed by the Ministry's research stations as a direct extension of their applied research programmes. Apart from these, however, the Ministry also negotiates contracts centrally for support of industrially important research and development programmes. Since the Ministry is not generally a user department, proposals from firms in this latter context must be for work which they wish to do themselves and for which they are prepared to bear part of the cost. To merit support, projects must be in the general national interest and must also incorporate a substantial technological advance. Proposals from industry will be examined in the first instance to determine whether support is appropriate to the National Research Development Corporation or should take the form of a cost-sharing contract from the Ministry itself. All applications are regarded as confidential and are handled with strict regard to commercial security.

The Ministry has four main types of contract with which it can directly support industrial research and development or industrially orientated research in universities and research institutions:

(a) *Co-ordinated research and development contracts*
Where a group of firms wish to do work in the same field, a mechanism has been evolved to achieve a degree of co-ordination. The Ministry is prepared to give support on a half-share basis where an additional effort can be contributed by its own research establishments, and possibly more where all the work will be done in industry. Contracting firms may safeguard their own know-how, but full information is supplied to the Ministry and state-of-the-art reports are circulated to other participating firms. Provision is made in the contract for a negotiable levy to be applied to the sale of any end-product emerging, and in addition the Ministry is entitled to a share of the proceeds of any patents arising.

(b) *Research Contracts*
Research contracts are designed to support a group of firms and organizations with related interests which agree to co-ordinate their activities in relation to a specific programme of applied research. Support is offered on the basis of a full interchange of the results of the work and full publication of these results after the end of the contract, where this is deemed advisable in the interests of British industry as a whole. The only way in which the Ministry attempts to recover its contribution in this type of contract is by a share in the proceeds of any patents arising.
Research contracts of this type will naturally complement, not duplicate, the co-operative efforts of the research associations: it is the Ministry's intention to support the best qualified teams, wherever they may be found.

(c) *University research contracts*
Where a university wishes to do work which is industrially orientated, the results of which are felt to be in the national interest, contract support will be offered: direct co-operation between the university and industry is particularly encouraged. Full co-ordination is maintained by the Ministry with the Science Research Council.

(d) *Contracts placed by Ministry stations*
Where a research station requires research or development work to be done as an extension of its own applied research programme, it places the necessary contract and, if it pays the full cost, retains rights in the results.

In all support given by means of contract the following general conditions will apply. The limits of the Ministry's financial contribution, the technical specification for the work and a timed programme will be agreed in advance. A technical authority will be nominated by the Ministry (where appropriate, one of its own establishments) to co-operate with the organizations concerned and give the best technical advice available from Government sources. The Ministry welcomes proposals from British industry on the above basis.

General information on the organization and activities of the Ministry, its research stations and the industrial research associations it supports,

can be obtained from the Regional and Industrial Services Branch of the Ministry at the following address:

Ministry of Technology
Abell House
John Islip Street
London, SW 1
Tel. 01-834 4422

or from any of the Ministry's regional offices throughout Great Britain.

CHAPTER 9

Safety Measures

According to the latest figures available at the time of writing from H.M. Inspector of Factories for the year 1964–5, the frequency rate for the chemical and allied industries was the fourth lowest group at 1·84 out of a total of sixteen industrial groupings. This means that there were only 1·84 lost-time accidents per 100,000 hours worked. A lost-time accident is one which causes the sufferer to be unable to work beyond the day or shift on which the accident occurred.

It therefore does great credit to the Chemical Industry that considering the nature of the materials and processes there are so few catastrophic accidents. This is largely due to the responsible attitude of the firms concerned and their intimate knowledge of the hazards of their materials, processes, and plant. Many safety measures are introduced and freely shared with other firms irrespective of whether or not there is any legal obligation to do so. In many cases firms themselves know more about the hazards than anyone else and so government regulations could hardly cater for them as effectively as do firms' own voluntary safety measures.

Safety starts at the design stage and there is a good treatment of this aspect of the subject in J. H. Perry, *Chemical Engineers' Handbook*, 4th edn. (McGraw-Hill, New York, 1963) (Fig. 13).

The following is an invaluable guide for the Chemical Industry: *Safety and Management*, 4th edn. (Association of British Chemical Manufacturers, London, 1964, now Chemical Industries Association Ltd., Alembic House, 93 Albert Embankment, London,

SE 1). Each chapter and section is laid out under the following headings:

1. Principal requirements.
2. Legal requirements.
3. Cross-references.
4. Detailed instructions.

Chapter headings are as follows: Fire, Explosion, Gassing, Poisoning and Dust Inhalation, Corrosive Substances, Safe Working in Confined Spaces, "Permit to Work" Certificates, Medical and First Aid Certificates, General Working Conditions and Safety, Personal Protective Equipment, Ionizing Radiations.

There is much good general advice in this book, such as, for example, on lighting, works tidiness, and cleanliness, and it is well indexed.

The main hazards of chemical works are: fire, explosion, poison, corrosion, and radioactivity. In addition there may be unexpected dangers to users of chemicals; each of these is dealt with later in this chapter. Regarding electrical safety in general, the following is available, W. F. Cooper, *Code of Electrical Safety* (British Safety Council, 63 Praed St., London, W 2).

Sources of Information about Safety

In this section we have again selected representative sources of information as an indication of what is available. Probably the best trade directory in this field is *Industrial Safety Equipment and Clothing Catalogue* (United Trade Press, London, annually). Other general publications include:

Ministry of Labour, *Accidents: how they happen and how to prevent them* (HMSO, London, quarterly).

British Journal of Industrial Safety (Royal Society for the Prevention of Accidents, London).

Industrial Safety Bulletin (Royal Society for the Prevention of Accidents, London, monthly to members only).

Safety News (Royal Society for the Prevention of Accidents, London, monthly).

The Institute of Safety Officers publishes a monthly *Journal*, whilst the following is useful particularly for its advertisements: *Industrial Safety* (United Trade Press, London, monthly).

For information about protective clothing, etc., the following is a good source: *Industrial Safety* (*Personal Equipment*) (Manufacturers Association, 6 Holborn Viaduct, London, EC 1, Tel. Holborn 6031). However, for headgear in particular, the corresponding organization is the Protective Headwear Manufacturers Association, 60 Cannon St., London, EC 4 (Tel. City 4444).

For all general safety matters in the Chemical Industry the following is the key source: British Chemical Industry Safety Council of the Chemical Industries Association, Alembic House, 93 Albert Embankment, London, SE 1. This Council is composed of directors of firms which are members of the CIA; its objectives are to maintain the high standards of safe working already achieved in the industry and to improve and extend safe working practices. It co-ordinates the safety and medical activities of the CIA, including the collection and analysis of accident statistics, advice to the industry on medical and technical matters affecting the health and safety of its employees, and the issue of advisory pamphlets. These pamphlets include such titles as:

Safety Organization in Small Works.
Industrial Dermatitis.
Medical Supervision in the Chemical Industry.
Safety in Inspection and Maintenance of Chemical Plant.
Protection of the Eyes.
Safety Training—A Guide for the Chemical Industry.
The Prevention and Control of Dust-Diseases in Industry.
Housekeeping Competition.

Of these publications, *Housekeeping Competition* is probably the most generally applicable to all departments (including offices) of chemical works. A system of penalty marks is deducted from

the points-rating initially given to various areas of the works, while bonus marks are added for accident-free periods and for improvements. The penalty marks cover general tidiness, obstruction, protective clothing (failing to wear or if defective), fire precautions, general protection, and hygiene. Finally, prizes and awards and publicity are suggested in order to maintain the competitive spirit.

The professional body for industrial medical officers is the Society of Occupational Medicine, Royal College of Surgeons, Lincoln's Inn Fields, London, WC 2 (Tel. Holborn 3474), which publishes the proceedings of the Society in *The Transactions* (quarterly). For supervisory staff, courses in job-safety are organized as part of the "training within industry" scheme by Ministry of Labour (TA7), Ebury Bridge House, Ebury Bridge Rd., London, SW 1 (Tel. Sloane 9661). The British Safety Council, Mason House, 163 Praed St., London WC 2 (Tel. Ambassador 2415), helps the accident-prevention movement by providing publicity and organizing conferences and courses for safety officers, etc.

For general guidance including firms' obligations under statutary requirements, the local alkali inspector should be consulted, details of whom are obtainable from the Chief Alkali Inspector, Ministry of Housing and Local Government, Whitehall, London, SW 1 (Tel. Whitehall 4300).

There are many additional works on safety in the Chemical Industry and the following are only a few of them:

P. I. Gaston, *Care, Handling and Disposal of Dangerous Chemicals* (Northern Publishers, Aberdeen, Scotland).

N. Sax, *Dangerous Properties of Industrial Materials*, 2nd edn. (Reinhold, New York, 1963).

A. and E. Rose, *Condensed Chemical Dictionary*, 6th edn. (Reinhold, New York, 1961).

H. H. Fawcett and W. S. Wood, *Safety and Accident Prevention in Chemical Operations* (Wiley-Interscience, New York, 1965).

In addition the following selection of safety publications are all

published by the Association of British Chemical Manufacturers which is now known as the Chemical Industry Association, London:

Marking Containers: a system of warning labels for containers of hazardous chemicals.
Papilloma of the Bladder in the Chemical Industry: a study of its cause and prevention.
Safety Circulars.
Code for the Storage and use of Highly Inflammable Liquids.
Safe Transport of Hazardous Chemicals.
A System of Labels for Gassing Casualties.

Plant Safety Officer

Probably the first and most important single step in organizing safety in a chemical works is that an individual should be made responsible for safety and he will then be known as the Safety Officer. In the smallest firms this may occupy only part of his time but at least then there is no doubt about responsibility for dealing with hazards by means of preventive measures.

Other responsibilities of the Safety Officer usually include reporting all accidents and inspecting plant and safety equipment, such as goggles and first-aid boxes. The plant inspection should be independent of production control in order to avoid risk of compromise. Non-destructive tests are often required and in this case the professional body is the Non-destructive Testing Society of Great Britain, 10 Chalfont Close, Leigh-on-Sea, Essex.

The plant Safety Officer is, in many cases, responsible for safety training and frequently he may use films for this purpose. Many firms' films are available on loan free of charge, such as ICI's inspired *Black Monday*. Individual firms, such as ICI, Shell, and Unilever in Britain, issue their own film catalogues which also include many films which are not concerned with safety. In addition, the following film-catalogues are published and include

details of films on safety of interest to those in the Chemical Industry:

Central Office of Information Film Catalogue (Central Office of Information, Hercules Rd., Westminster Bridge Rd., London, SE 1).

National Film Catalogue (55 Welbeck St., London, W 1).

Petroleum Film Bureau Catalogue (4 Brook St., London, W 1).

Further information about safety training is available in *Safety Training* (3 issues per year) Royal Society for the Prevention of Accidents, London.

Various Hazards

Explosion

In Britain the government departments mainly concerned with the safety aspect of explosions are:

1. Home Office Explosives Branch, Thames House, Millbank, London, SW 1 (Tel. Victoria 1288).
2. Safety in Mines Research Establishment, Ministry of Power (Buxton Laboratories), Harpur Hill, Buxton, Derbyshire (Tel. Buxton 2644).
3. Joint Fire Research Organization, Boreham Wood, Elstree, Herts. (Tel. Elstree 1341).

It is perhaps not generally realized that even innocent materials such as wheat or coal, when dispersed as a dust in air, can be violently explosive. The Fire Protection Association, Aldermary House, Queen St., London, EC 4 (Tel. City 5222), have published a concise leaflet available free of charge entitled *The Explosion Hazard from Flammable Dusts.*

Fire

One of the best sources of technical information in Britain on fires of all types is the Joint Fire Research Organization, Boreham Wood, Elstree, Herts. (Tel. Elstree 1341). The Fire Protection

Association and the Fire Offices Committee are both at Aldermary House, Queen St., London, EC 4 (Tel. City 4477). The Fire Offices Committee is a body of insurance companies which have an interest in fire insurance, and the Fire Protection Association is the central advisory organization, largely financed by these insurance companies and Lloyds to provide general advice on all aspects of fire protection. It publishes a quarterly *Journal* and *Fire Bulletin*. In addition, the Fire Protection Association publishes a large number of highly specialized technical information sheets and booklets such as

Precautions in the Use of Cylinders of Dissolved Acetylene.
Buildings for the Storage of Flammable Liquids.
Fires in the Chemical and Allied Industries.
Spread of Fire by Bituminous Roof Coverings.

The professional body for fire protection officers is the Institute of Fire Engineers, 94 Southwark Bridge Rd., London, SE 1 (Tel. Waterloo 5704). The corresponding employees organization is the National Association of Fire Officers, Palace Chambers, Bridge St., London, SW 1 (Tel. Trafalgar 5011). The corresponding directory is *Fire Protection Directory* (Benn Bros., London, annually).

Poison

Poisons may enter the body through the mouth, the nose and eyes, wounds, or through the skin. In addition, all gases can cause suffocation by simply excluding oxygen. Common antidotes are listed and are available in poster form for display. Amongst others these posters are published by the British Drug Houses, Broom Rd., Poole, Dorset.

In Great Britain and Eire, poisons information is available to doctors 24 hours a day at the following addresses in order to deal with emergency inquiries:

National Poisons Information Service, Guy's Hospital, London, SE 1 (Tel. Hop 7600).

Scottish Poisons Information Bureau, the Royal Infirmary, Edinburgh, 3 (Tel. Fountainbridge 2477).

The Poisons Information Centre, Cardiff Royal Infirmary, Cardiff (Tel. Cardiff 33101).

The Poisons Information Centre, Royal Victoria Hospital, Belfast, 12 (Tel. Belfast 30503).

The Poisons Information Centre, Jervis Street Hospital, Dublin (Tel. Dublin 45812).

In addition the following will give advice to ANY inquirer:

General Infirmary, Leeds (Tel. Leeds 30715).

Similar organizations have been set up in many other countries including Belgium, France, Holland, Norway, and Sweden and also Australia and New Zealand in addition to USA and Canada. The co-ordinating centres in each case form good sources of information regarding the detailed arrangements in particular areas; these are as follows:

European Association of Poisons Control Centres (Association Européenne des Centres Poisons), Hospital Fernand-Widal, 200 rue du Faubourg-Saint-Denis, Paris, France.

National Clearing House for Poison Control Centres, US Department of Health, Education, and Welfare, Public Health Service, Washington DC, 20201, USA.

Canadian Clearing House for Poison Control Centres, Food and Drug Directorate, Department of National Health and Welfare, Tunney's Pasture, Ottawa, 4, Ontario, Canada.

Amongst the emergency books on poisons are G. W. H. Lucas, *The Symptoms and Treatment of Acute Poisoning* (Macmillan, New York, 1953) and V. J. A. Brooks and M. B. Jacobs, *Poisons: Chemical Identification, Symptoms and Emergency Treatment*, 2nd edn. (Van Nostrand, New York, 1958). A more analytical approach is to be found in M. B. Jacobs, *The Analytical Chemistry of Industrial Poisons, Hazards and Solvents*, 2nd edn. (Interscience, New York, 1949) and F. Bamford and C. P. Stewart, *Poisons*,

Their Isolation and Identification (Churchill, London). Other useful works include R. H. Dreisbach, *Handbook of Poisoning, Diagnosis and Treatment*, 4th edn. (Lange, Los Altos, Cal. 1963), and C. H. Gray, *Laboratory Handbook of Toxic Agents* (Prentice-Hall, Englewood Cliffs, NJ, 1961).

Radioactivity

Radioactivity in the Chemical Industry is largely confined to trace materials in the laboratory, and to leak detection, thickness measurement, and level gauging by means of sealed sources in production units.

In those laboratories in Britain where radioactive materials are being used, contact will have already been made with the nearest radiation protection officer, details of whom are obtainable from Isotopes Division, United Kingdom Atomic Energy Authority, Wantage, Berks. (Tel. Wantage 2911). In view of the very considerable quantities of radioactive materials exported to all parts of the world by the following, it is a useful source of information on rules and regulations concerning these materials not only while in transit but also in most countries of the world where they are used: Radiochemical Centre, Amersham, Bucks.

Interested readers should also see:

Radioactive Substances Act 1960 (HMSO, London).

The British Journal of Radiology (1955 suppl. 6 and 1958 **31**, 93).

J. C. Boursnell, *Safety Techniques for Radioactive Tracers* (CUP, Cambridge).

Automatic Safety Gear

With the growth in the reliability of electronic equipment, there are now many ways of detecting and making automatic adjustments to operating conditions in order to avoid danger. For example, if a reaction must proceed within a given temperature

range, it is now normal to link a temperature-sensing device with the flow control of the heating or cooling medium. To take another example, many chemical processes are continued 24 hours a day and if the levels of liquids in tanks were to rise or fall too much, a disastrous situation could arise. It is now a simple matter to link the level gauge with not only the usual visual and audible alarms but also with an automatic telephone-dialling device which will telephone several key personnel in turn and announce in plain words what has happened.

Two of the best sources of information about their respective members' automatic safety devices for chemical plant are: SIRAID, British Scientific Instrument Manufacturers' Research Association, South Hill, Chislehurst, Kent (Tel. Imperial 5555), and British Chemical Plant Manufacturers' Association, 14 Suffolk St., London, SW 1 (Tel. Whitehall 0766).

In addition, the following government laboratory may be able to help in certain cases: Warren Spring Laboratory, Stevenage, Herts. (Tel. Stevenage 2080).

Safety for the User of Chemicals

Before a new chemical performs its function as, say, a pigment for food or cosmetics, it has to be examined and tested in order to see that it is in no way toxic. Although the larger firms can do this work themselves it is often necessary to have such tests carried out objectively by an independent body. The following is pre-eminent in this field: British Industrial Biological Research Association, Woodmansterne Rd., Carshalton, Surrey (Tel. Melville 4411). There are a few sponsored research and testing organizations which do this work, for example Arthur D. Little Research Institute, Inveresk, Midlothian, Scotland (Tel. Musselborough 2434), and Huntingdon Research Centre, Cromwell House, Huntingdon.

In Britain the Ministry of Health has set up a Committee on Safety of Drugs and details of this and other committees concerned with pesticides and toxic chemicals, antibiotics,

pharmaceuticals, and occupational health are all obtainable from Department of Education and Science, *Chemicals Additives and Drugs* (HMSO, London, 1966).

Safety in Chemical Laboratories

For a brief outline of the principles of safety in chemical laboratories, a useful booklet as follows is widely used in the Chemical Industry in Britain: *Safety in Laboratories* (Geigy UK, Simonsway, Manchester, 22). This gives general advice aimed at reducing risks in laboratories: interestingly, Geigy state that:

1. The human factor is directly responsible for five out of every six accidents.
2. Fire is the major laboratory hazard.
3. The younger the laboratory worker, the more likely he is to have accidents.

A standard work on safety in laboratories is Laboratory of the Government Chemist, *Safety Measures in Chemical Laboratories* (HMSO, London).

In laboratories, the head of the laboratory will usually be responsible for safety; this will include ensuring that all laboratory workers are familiar with the safety facilities and rules to eliminate accidents. The following is a particularly useful work in this regard: C. H. Gray, *Laboratory Handbook of Toxic Agents* (Prentice-Hall, Englewood Cliffs, NJ, 1961).

CHAPTER 10

The Computer in the Chemical Industry

ALL aspirants to careers in the Chemical Industry, whether technical or non-technical, should have some understanding of the working and potentiality of the computer: indeed this applies to industry in general and to the professions, and will ultimately be required of what is called "a good general education". In the same way that the Industrial Revolution of the last century led to the replacement of our own muscular energy with mechanical energy, the computer developments will lead to the replacement of some of our mental activities (particularly in planning and organizing) with the "logical steps" of the computer.

In a way that is only slowly becoming apparent, almost every aspect of life—science, the arts, industry and commerce, government, and even the common round of daily living—will depend more and more on computers and systems of automation.

There is no need to understand fully the intricate construction of the computer—after all we use the telephone and enjoy television without understanding in detail how they work—but it is essential to have an understanding of the general principles and an appreciation of what they can and cannot do in order to make intelligent use of them. This chapter will endeavour to introduce the subject with special reference to the Chemical Industry.

An excellent introduction to the whole subject is given in B. V. Bowden (Ed.), *Faster than Thought*, a symposium on digital computers (Pitman, London, 1953). Although old by today's standards, this book is still of interest and by far the best introduction to the subject.

Another equally popular introduction is E. C. Berkeley, *Giant Brains, or Machines that Think*. In spite of the "pop" type title this is a serious contribution and explains things well.

The credit for the earliest conception of the computer is usually given to Charles Babbage working at Cambridge University in the early nineteenth century. Unfortunately the engineering technology of his time was not sufficiently advanced to allow him to put his ideas into practice.

The first electronic computer was the ENIAC, built by the Moore School of Engineering at Pennsylvania University during World War II to produce mathematical tables required for the firing of projectiles. The EDSAC, built in 1949 by the Mathematical Laboratory at Cambridge, was the first computer with a stored programme (or "memory"). Another early computer was the ACE, designed by the National Physical Laboratory in 1945 but not completed till 1950. The first computer to be marketed commercially was the Manchester Mark I designed and built in 1950 as the result of collaboration between Ferranti Ltd. and Manchester University. These dates emphasize the rapid growth of the Computer Industry as less than 20 years have passed since these prototypes were introduced.

They were first used for scientific calculations in universities and research and engineering organizations. Although the calculations involved are complex and very great in number, dealing as they frequently do with the solution of mathematical equations, the programming is comparatively simple.

Next they were applied to business calculations in industry and commerce, a development arising from the original punched-card tabulation techniques. Then, in 1960, it was felt that computers had become sufficiently reliable to take over the control of even complex industrial processes and in the few years since then they have been applied to many manufacturing processes, including chemical processes.

The Modern Computer

Analogue and Digital

There are two distinct types of computer, the analogue and the digital. These names refer to the method used in each to represent numbers. In the analogue computer the physical quantity being measured (e.g. flow, speed, temperature, etc.) is represented by another physical quantity (e.g. length, angle of turning, voltage, etc.). In the digital computer the number is represented by actual digits.

Books which introduce the two types are:

K. A. Key, *Analogue Computing for Beginners* (Chapman & Hall, London, 1965).

N. R. Scott, *Analogue and Digital Computer Technology* (McGraw-Hill, New York, 1960).

G. A. and T. M. Korn, *Electronic Analogue and Hybrid Computers* (McGraw-Hill, New York, 1964).

The simplest analogue device is the slide-rule. Distance along the rule represents the logarithm of a number, and by adding together the logs of two numbers the product log is found so that adding together the lengths on the scale gives a simple method of multiplication. Similarly, division is done by subtracting lengths, square roots by halving lengths, and so on. The essential difference between the two types is that digits are separate isolated units, whereas the analogues are continuous. Nevertheless, the analogue computer is not so accurate as the digital as it depends for its accuracy on the accuracy with which a line can be drawn or an angle turned, etc. They are very useful, however, for simple systems where the digital computer would be too expensive and they *are* often incorporated into overall digital control systems to fall back on if the digital computer fails.

The analogue computer is generally designed to do one job only, whereas the digital computer, in addition to its greater accuracy,

has also the advantage of being able to store both data and instructions to be used when required, and to perform logical functions. It can therefore be converted to do any number of similar jobs by making changes in the "program",* thus being very much more versatile.

Examples of both principles are contained in the modern motorcar in one assembly: the speedometer uses pointer-angle as the analogue of speed, and the mileage indicator, which is a counter, measures distance in terms of digits.

One frequently quoted distinction between the two types of computer is that the analogue computer answers "how much?" and the digital computer "how many?". Digital computers are fundamentally similar in design because the task of counting "how many" always relates to figures or digits and the processing is the same. Analogue computers are usually designed for a special task and the factors to be measured differ in their nature. Some measure time, others distance, force, heat, flow, etc.

It will be seen, therefore, that when one comes to consider the direct digital control of chemical manufacturing processes, although the overall control can be by digital computer, analogue quantities are involved since the plant parameters are "analogue" in nature, e.g. the flow of liquid in a pipe is a smooth, continuous movement.

Books on the digital computer tend now to be somewhat too technical for the layman but the following will provide a useful coverage of the subject:

P. Siegel, *Understanding Digital Computers* (Wiley, New York, 1961).

T. C. Bartree, *Digital Computer Fundamentals* (McGraw-Hill, New York, 1960).

E. L. Braun, *Digital Computer Design* (Academy Press, New York, 1963).

* We accept this spelling as of international usage in computer literature.

The Set-up

Fundamentally the computer can do addition, subtraction, multiplication, and division; it has the ability to take logical decisions and act in different ways according to the results. For example, it can compare two numbers, and if A is greater than B

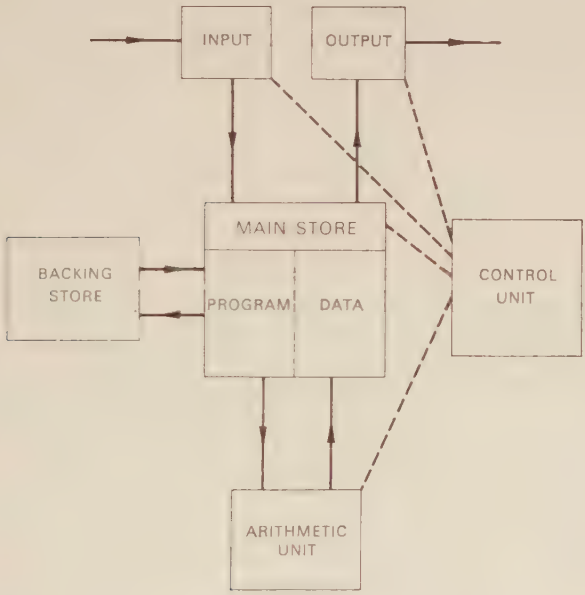


FIG. 16. The basic parts of the computer.
(By permission of Ferranti Ltd.)

it takes certain action, but if B is greater than A it takes another type of action.

The program breaks down the problem into simple steps so that at each step the computer is faced with two alternatives and decides on one of them.

There are five basic parts to the computer, and these are illustrated in Fig. 16.

1. The arithmetic unit, where the calculations are carried out.
2. The main store (or immediate-access store), where the program instructions and the data used in the calculations are stored.
3. The backing store, which receives those instructions and data not actually in use in the exercise being processed.
4. The input and output units, which constitute the communication of the computer with the outside world, the input being the receipt of instructions and data and the output the giving of answers.
5. The control unit interprets the instructions held in the program store and causes them to be obeyed.

The Arithmetic Unit

Normally we do our arithmetic using the decimal system of numbers, with 10 digits, 0–9. When one of these digits stands alone or occupies the right-hand column it indicates that number of units, but as it is moved to the left to the second and third columns it represents tens and hundreds respectively. For example the number 4285 is a short way of writing

$$(4 \times 10^3) + (2 \times 10^2) + (8 \times 10^1) + (5 \times 10^0) = 4285.$$

In this case we say that the "radix" of the system is 10.

It is possible to use number systems based on another integer as radix, and the computer uses a system based on 2, called the binary system. This uses only two digits, 1 and 0, which makes the electronic engineering problem a good deal simpler, although a number in binary notation requires about three times as many digits as when expressed in the decimal system. In the jargon of the computer these binary digits are called "bits".

It will be readily appreciated that the construction of two-state electronic devices to indicate the digits 1 and 0 is a much simpler proposition than, say, ten-state devices to indicate the 10 digits 0–9.

Examples of two-state devices which can be used are these—a switch may be either on or off, a relay open or closed, a transistor either conducting or not conducting, a piece of magnetic material magnetized in either one direction or the other, or the two digits may be represented by two voltage leads.

Another reason for using the binary system is that logical "yes/no" decision problems can be dealt with satisfactorily using the logical algebra known as "Boolean Algebra".

There is a very good chapter on Boolean Algebra in the book E. L. Braun, *Digital Computer Design* (Academic Press, New York, 1963).

Binary Arithmetic

As explained above, the binary system has only 2 digits, 1 and 0. The radix being 2 instead of 10, the digit 1 doubles in value each time it is moved one column to the left. The digit 0 has no value and is used as in the decimal system merely to indicate the columns in which there is no value. The following few examples will explain:

Decimal	*Binary*
1	0001
2	0010
3	0011
4	0100
5	0101
9	1001
15	1111
159	10011111
501	111110101

The last two numbers indicate:

$$2^7 + 0 + 0 + 2^4 + 2^3 + 2^2 + 2^1 + 2^0 = 159$$
$$2^8 + 2^7 + 2^6 + 2^5 + 2^4 + 0 + 2^2 + 0 + 2^0 = 501$$

The process of addition is carried out by adding the digits column by column, e.g.:

111110101	501
10011111	159
1010010100	660

The few simple rules are:

$0 + 0 = 0$
$1 + 0 = 1$
$1 + 1 = 0$ (and carry 1 to next column)
$1 + 1 + 1$ carried $= 1$ (and carry 1 to next column)

Similarly with subtraction:

111110101	501
10011111	159
101010110	342

It can readily be seen that multiplication and division can also be done, and conventions exist to deal with fractions and negative numbers. This will be sufficient, however, to show how important the binary system is to the computer, the 2 binary digits being simply expressed by the operation of the two-state electronic devices.

Binary arithmetic is more fully explained in N. A. Crowder, *The Arithmetic of Computers*, 3rd edn. (EUP, 1962).

There has therefore to be a method of connecting different circuits so that a number in one circuit can be combined in the required way with a number in another circuit. This is done by applying the numbers to a series of electronic "gates", described as "AND gates" and "OR gates". The "OR gate" is a 2 input circuit which produces an output pulse on receiving an input pulse on one or the other input, but not on both inputs at the same time. This corresponds with the following of the simple rules of binary addition (above): $1 + 0 = 1$; $0 + 0 = 0$; $1 + 1 = 0$ (but it fails to

carry forward 1 to the next column). To achieve the carry forward the "OR gate" has to be used in conjunction with an "AND gate", which produces an output pulse only when there is an input pulse on *both* inputs. It is by the proper combination of these and such like gates within the circuit that the necessary processes are carried out within the arithmetic unit, so that the four essential rules of binary arithmetic may be obeyed. What goes on in the arithmetic unit is frequently referred to as "processing".

The Program

Before the computer can do any work whatsoever it must be given clear instructions, called the program, which enters through the input unit and is then held in the main store. The problem it has to solve must be broken down into its individual steps and stages. These must be expressed in one of the special "programming languages" which have been evolved for the computer, and fed into the computer in such a form which will actuate the various "AND/OR gates" and the on–off devices. The chief programming languages are COBOL (an international high-level commercial language), FORTRAN (an international high-level scientific and technical language), and ALGOL (an international high-level scientific language intended essentially for research purposes). These languages assist discussion between computer experts and the other specialists requiring the information: they also enable instructions to the computer to be given promptly and efficiently.

Useful guides to programming are as follows:

H. O. Leeds and G. M. Weinberg, *Computer Programming Fundamentals* (McGraw-Hill, New York, 1961).

B. A. M. Moon, *Computer Programming for Science and Engineering* (Butterworths, London, 1967).

R. Nathen and E. Hanes, *Computer Programming Handbook: a guide for beginners* (Prentice-Hall, London, 1962).

H. Breuer, *Dictionary for Computer Languages* (Academic Press, New York).

The most obvious way of feeding in the program to the computer is by typing it on the control teleprinter which, in addition to producing the typed instruction on paper, generates a series of coded electronic pulses which are fed to the computer. The chief drawback to this otherwise convenient method is that its speed of transfer is limited by the speed of typing, which, of course, is far behind the ordinary working speed of the computer. A quicker way is to feed in the information in the form of punched cards, and this is a very usual method as, of course, the information existed in this form before the days of the computer, especially in relation to business statistics.

The cards are fed into a "reader", which defines the position of the punched holes optically or mechanically and again sends the appropriate electronic pulses through the input of the computer. Where the instructions are more complex or more numerous a punched paper-tape system is used—the paper tape being punched by the teleprinter at the time of typing. Each system has its own advantages, the punched cards allowing the taking of data from the middle of a program where some limited objective is required.

All these methods of feeding in the program are slow compared with the tremendous speed of the computer and it is for this reason that the program is usually drawn up by the programmer well before it is to be used, expressed in the appropriate programming language and fed into the computer to be stored till required.

The Store

Computer stores may be of different types—magnetic tape, magnetic drums or discs, magnetic cores. The last-named is the most common type for immediate-access stores, that is the store holding the program and data actually being used at a particular time. It uses large numbers of very small ferrite rings (only a few hundredths of an inch across) to represent one binary digit or "bit", as it is called. In the store each word (group of bits) has its own particular location, known as the "address", and all instructions and data are directed to different "addresses". Although a core store

can hold very many words in store, if there is a need for a large number of words beyond the capacity of the core store, some can be transferred to what is called a backing or auxiliary store. The backing store does not require to function at such high speed and the usual forms are magnetic drums or discs, or even magnetic recording tape.

Output

The answers from the computer are called "output" and there are many ways of recording this. The control teleprinter can be used but is slow compared with the normal computer speed. A faster procedure is to feed the computer information to a tape punch to produce punched tape which can be fed later into an individual teleprinter so that the computer working is not slowed down. If the output is very great and very fast a high-speed line printer (printing a whole line at a time and over a thousand lines a minute) may be used.

Sometimes the results are presented in the form of a graph or diagram and can be displayed by tracing the outline with a spot of light on the face of a cathode-ray tube. The list of possibilities is increasing rapidly as new requirements arise.

These units are frequently referred to as the "hardware" of the computer, and are in themselves the complete electronic equipment to carry out the processing of any program of work fed into it. That program must be worked out by man in the first place. A different program will be needed for each problem but once written a program can be used over and over again with different sets of data. Such programs and the auxiliary aids to their preparation are known as "software". Software provides the medium for communication between the computer and the user and is chiefly concerned with the input/output systems. It has been said that if electricity is the life-blood of the electronic computer, software is its mind.

It is true to say that the computer was made possible by the discovery of the thermionic valve, which is essentially a device that permits current to flow in one direction only.

The more recent discovery of transistors, which do almost everything the valve can do but can be made very much smaller and last longer, has led to a considerable reduction in size and weight of the modern computer. In fact a new way of wiring has become necessary, known as "the printed circuit". This is first made as a drawing, then printed on copper foil bonded on a base of glass fibre or plastic. The panel is formed by covering the copper with a photo-resistive substance, exposing to the negative and then immersing in acid. The copper not protected by the photo-resist is etched away leaving the desired circuit to which the components can then be attached. By this means the modern computers become very small and manageable.

It has thus become conventional to speak of the "generations" of computers, the first generation being based on thermionic valves and conventional wiring or even printed circuits; the second used transistors with conventional wiring or printed circuits; and the third (or present) generation is based on microcircuits (or integrated circuits) in which there may be as many as fifty transistors and components in one unit, and that unit may be no more than ¼-inch in diameter. The computer may have a thousand or so of these units.

Data Processing

The most regular application of computers to industry and commerce is in the collection, statistical assembly, and processing of the data relating to the everyday affairs of the company. By means of the computer the most important management statistics and information can be available as and when they are required. Such matters as turnover and stock control can be considered with figures which are correct at the time of consideration, not several days or weeks out of date. This means that decisions can be based on facts instead of "hunches".

The chief specific applications are stock control, wages, budgetary control, production, marketing, invoicing, financial forecasting, assessment of projects, and plant lay-out, and programs

can be readily available for these exercises and easily adaptable to individual cases.

Useful books on the computer for business purposes are D. Shirley, *Choosing a Computer* (Business Publications, London), and also the Bow Group booklet, *Computers in Britain.*

The transmission of data is another growing application, especially valuable to large and scattered organizations like the banks and the international air lines. Two systems are used, "off-line" and "on-line". In the former the information is punched on paper tape which is fed over the data link to the computer centre where an identical tape is generated. This tape is read into the computer immediately or held till required. Results are likewise communicated through the intermediary of paper tape. With the on–line working the data are sent over the wire straight into or from the computer store. The banks generally are working off-line and the air lines on-line. It is in this type of discussion that the computer jargon "real time" is used to indicate that the computer is processing data immediately they arise. The records are being continually up-dated and at any moment of time they reflect the exact position.

Another use of particular interest is in information retrieval. The modern computer, with its capacity to store vast quantities of records and references and to collate them in an orderly manner by subject, author, date, origin, etc., presents the possibility of bringing order into the masses of publications now available to workers in all fields. This is most likely to develop on the national and international scale.

See also A. D. and K. H. V. Booth, *Automatic Digital Calculators*, 3rd edn. (Butterworths, London, 1965). This is a well-established text and reference book, discussing history, logical, design, programming, FORTRAN language, applications, and the most recent micro-designs.

See also D. W. Morley, *Automatic Data Processing* (HMSO, 1961), and E. Mumford, *Living with a Computer* (Inst. of Personnel Management).

The Computer in the Chemical Industry

(a) Instrumentation

Automation is no new thing in industry, or even in the Chemical Industry, and for many years "instrumentation" has been common in chemical plants, each instrument performing its own function of recording data or controlling valves, levels, pressures, temperatures, or some such parameter.

A thorough general treatment of instrumentation is given in:

J. H. Perry, *Chemical Engineers' Handbook*, 4th edn. (McGraw-Hill, New York, 1963), which also contains a very extensive bibliography of specialized literature on this important topic.

The Instrument Manual (United Trade Press, London, 1953).

D. M. Considine, *Process Instruments and Control Handbook* (McGraw-Hill, New York, 1957). Both this and the previous title are extensively used in the Chemical Industry.

E. B. Jones, *Instrument Technology*, 3 vols. (Butterworths, London, 1957), is a standard work on this subject.

The foregoing are only a very limited selection of published sources of information. In addition much useful guidance can be obtained from both *British Chemical Plant* (British Chemical Plant Association, London, annually) and the *British Instruments Directory*, 3rd edn. (United Science Press, London, 1962).

In Britain, specific inquiries regarding instrumentation may be directed either to SIRAID, Scientific Instrument Research Association, Chiselhurst, Kent, or in some cases to Warren Spring Laboratory, Stevenage, Herts.

There are very many journals and the following are a few examples:

Instruments and Control Systems, Instruments Publishing Co., Pittsburg.

Instrument Engineer, George Kent, Luton.

Instrument Abstracts (monthly), Taylor & Francis, London.

Transactions and Journal, Instrument Society of America, Pittsburg.

In Britain, The Society of Instrument Technology, 20 Peel St., London, W 8 has twenty branches, and in the United States there is the Instrument Society of America, Pittsburg. Both can be used as good sources of information.

(b) Computer Control

The complexity of certain chemical plants with great numbers of instruments (most of them individual analogue controls) means that the number of adjustments and decisions to be made by the operator becomes too much for him. At the same time the economic pressure of today demands higher and higher output, greater efficiency, and better products at lower cost, so that the many complicated and varied demands upon plant operatives and supervisors continue to increase.

On large plants there is therefore a strong case for direct digital control by computer, and several installations are already operating in this country, mostly on continuous processes. The important computer characteristics in this field lie in their speed of working and in their ability to take logical decisions—the yes/no decisions previously discussed. These are more important than the calculating and storage facilities, although both are essential but in much reduced form compared with the data-processing computers which must have a large storage capacity and large calculating facility. For process control work the computer therefore requires its arithmetic unit (for high-speed calculation and decisions), a data store (for holding data and information), and a program store (for holding the sequence of operations).

The computer will be attached to the plant on-line so that it becomes part of the plant and receives information direct from the plant as it actually occurs, that is to say in real time. The information is processed immediately and the results returned to the plant, usually as a control signal to adjust a valve or some other control unit.

Recent books on this subject are:

E. S. SAVAS, *Computer Control of Industrial Processes* (McGraw-Hill, New York, 1965).

H. H. ROSENBROCK and C. STOREY, *Computational Techniques for Chemical Engineers* (Pergamon, Oxford, 1966).

P. S. BUCKLEY, *Techniques of Process Control* (Wiley, New York, 1964).

L. LAPIDUS, *Digital Computation for Chemical Engineers* (Prentice-Hall, 1962).

HARRIOT, *Process Control.*

A. D. BOOTH, *Automation and Computing*, 2nd edn. (Staples Press, London, 1966).

A most useful compilation of literature references has been issued which well merits examination, C. R. Randall, *A Select Bibliography on Computer Applications in Commerce and Industry*, published by Hertfordshire County Council Information Service.

Considerable work on computer control is being carried out, for example at Warren Spring Laboratory, Stevenage, Herts, and the University of Manchester Institute of Science and Technology, and, amongst others, ICI and the Distillers Company have large plants operated by this method.

Careers

It will be realized that the computer itself will make certain demands on trained staff at all levels and at all stages of its installation and operation. Once installed it will gradually accumulate data and information on the behaviour of the plant and the parameters of the process so that chemists and chemical engineers will have new opportunities presented to them in process control.

There are positions also for programmers, specialists in business techniques, systems analysts, hardware specialists, software specialists, instructors, and many others only too obvious from the advertisement pages of the Sunday newspapers.

Other Information

In addition to the books referred to throughout this chapter the chief sources of information on computers are, of course, the computer manufacturers themselves, who issue plenty of explanatory literature and run regular courses of instruction in various aspects of the subject at reasonable fees.

Information can also be obtained from the British Computer Society, Finsbury Court, Finsbury Pavement, London, EC 2, or from the Society Library, which is housed at Leicester College of Arts and Technology, Leicester.

To keep up to date with any particular specialization there is a useful publication, *Computer Abstracts*, published monthly by Technical Information Company, Martins Bank Chambers, PO Box 59, St. Helier, Jersey, Channel Islands.

There are also a number of journals dealing with business aspects or technical aspects, of which the following are representative:

Control (*Systems*, *Instrumentation*, *Data Processing*, *Automation*, *Management*) (monthly), Morgan Bros. Ltd., 28 Essex St., Strand, London, WC 2.

Data Processing Magazine (monthly), North American Publishing Co., 134, North 13th St., Philadelphia, Pa.

Data Processing Journal, published by International Computers and Tabulators Ltd. (ICT), Putney, London, SW 15.

Data Processing (every two months), Iliffe Electrical Publications Ltd., Dorset House, Stamford St., London, SE 1.

Systems (monthly), United Business Publications Inc., 200 Madison Ave., New York.

Cuyahoga Community College Library

INDEX

General and Organizations

Abbreviations: A. = Association. I. = Institute. In. = Institution. M. = Manufacturers. Nat. = National. R. = Royal. Res. = Research. Soc. = Society.

Accident rates 174
Accidents, R. Soc. for Prevention of 179
Accountants
  A. of Certified and Corporate 40
  I. of Chartered 40, 87
  I. of Cost and Works 40, 87
Acetylene 11
Adaptability 29
Adhesive M.A. 94
Adhesives 93
Aerosol M.A., Br. 133
Aerosol propellants 133
Agricultural Chemicals, A. of Br. M. of 123
Agricultural Contractors, Nat. A. of 104, 123
Agricultural Economics Res. I. 104
Agricultural Education A. 105
Agricultural and Horticultural Res. Sn., Long Ashton 104
Agricultural Res. Council 104
Agricultural Soc. of England, R. 105
Agricultural Soc. of Scotland, R. Highland and 105
Agricultural Soc., R. Ulster 105
Agricultural Soc., R. Welsh 105
Agriculture 92, 102
Agronomy, Unit of Experimental 104
Alchemists 4
Alkali (soda ash) 5, 11
American A. for the Advancement of Science 91
American A. of Textile Chemists and Colorists 91
American Chemical Soc. 66, 149, 160
American I. of Chemical Engineers 70, 91
Ammonia 11
Analytical chemistry 113–114
  Soc. for 39, 82
Animal Diseases Res. A. 144
Animal Health Trust 144
Anti-corrosion 111, 114
Anti-oxidants 111
Antiseptics 96
Appointments boards 44, 46
Aromatic Compound M.A., Br. 102
Arts graduates 36, 38, 40, 41
Aslib 162

Babbage, Charles 186
Bacon, Francis 4
Benzotriazole 114
Binary arithmetic 191
Biochemical Soc. 57, 69, 81
Biochemists 34, 57
Biological Res. A., Br. Industrial 108, 183
Biologists 3, 34, 57
Biology, I. of 57
Black Monday 178
Book titles *see separate index*
Boyle, Robert 4

Careers 29, 44, 185, 200
masters 45
Res. and Advisory Centre 48
Casein 93
Casein Glue M.A. 94
Casters' Technical A., Br. Investment 110
Cast Iron Res. A., Br. 110
Caustic soda 6, 11
Chartered Accountants, I. of 40, 87
Chemical Council 81
Chemical and Dyestuff Traders' A., Br. 84
Chemical engineers 3, 31, 32, 34, 55
Chemical Engineers, In. of 55, 69, 76, 81
Chemical Industries A. 27, 76, 83, 92
Chemical industry
abstracts 66
American 30
and Government 88
as growth industry 16
crafts 3
definition 1
exports 36
history 3, 10
impact on society 2
in aircraft 2
in clothing 2
in food production 2
in furnishing 2
in medicine 2
in motor-cars 2
in plastics 2
information and library 42
literature 60
literature, guides 75
literature, periodicals 67, 70 (*see also separate index*)
manufacturers, U.K. 44
manufacturers, U.S. 30
marketing 36
O.E.C.D. report 1967 26
overseas companies in U.K. 16
patents 43
personal suitability for 46
personnel 40, 44
post-war rationalization 9–10
production 31
publicity and public relations 41
purchasing 38
research and development 33
sales 35
secretarial/accounts 39
specialized industries 18, 30, 45, 92
statistics 16, 20
transport 41
Chemical Industry Safety Council, Br. 176
Chemical Industry, Soc. of 70, 81, 116
Chemical I. of Canada 71
Chemical M., A. of Br. 17, 30, 44, 76
Chemical Plant M.A., Br. 84, 183
Chemical products, classification 17
Chemical reaction 1
Chemical Soc. 66, 81
Chemical Specialities M.A. 138
Chemical Workers' Union 70, 86
Chemistry 3, 31
Chemistry, R.I. of 49, 50, 53, 76, 80
Chemists 3, 31
Chemists, Br. A. of 85
Chlorine 11
Chromium 12
City and Guilds of London I. 51, 55
Colour Makers' A., Br. 129
Colour M.A., Br. Artists' 129
Commonwealth Universities, A. of 59
Computers 40
analogue 187
arithmetic unit 190
ACE 186
backing store 190, 194
control unit 190
data processing 196
digital 187
ENIAC 186
EDSAC 186
hardware 195
input and output 190, 195
main store 190, 194
program 193

Concentrate M., Nat. Council of 108
Consultants 160
Consulting Engineers, A. of 81
Consulting Scientists, A. of 81
Corrosion Engineers, Br. A. of 116
Corrosion Group, Br. Joint 116
Cost and Works Accountants, I. of 40, 87
Cotton, Silk and Man-made Fibres Res. A. 100
Courses, technological 92

Dairy 95
DALTON, JOHN 5
Definition, chemical industry 1
Degree courses 50–51
Détergence, Comité International de la 96
Detergents 15, 95
Development Associations 168
Dish-washing 95
Disinfectant M.A., Br. 97
Disinfectants 96
Dry-cleaning 95
Dyeing 92, 98
Dyeing auxiliaries 142
Dyers' and Cleaners' Res. A. 100
Dyers and Colourists, Soc. of 100, 143
Dyers' and Finishers' A. 142
Dyers and Finishers, Employers' Fed. of 143
Dyers and Finishers, Fed. of Piece 143
Dyes 8, 12, 98
Dyestuffs Act 9
Dyestuff Traders' A., Br. Chemical and 100

East Malling Res. Stn. 104
Economic Development Council for Chemical Industry 88
Egg Packers, Nat. A. of Frozen 108
Electrical Engineers, In. of 81
Electroplating additives 114
Entomological Soc. of London, R. 125
Essence Export Group 102
Essence M.A., Br. 101
Essential oils 100
Explosion 179
Explosives 102
Explosives Branch, Home Office 179
Export, I. of 36, 88
External degree 52

Faraday Soc. 81
Farm and Garden A., Women's 105
Fertiliser Soc., The 105
Fertilizer M.A. 104
Fertilizers 102
Fertilizers, A. of Br. Organic and Compound 104
Films 76, 178
Fire Engineers, I. of 180
Fire Extinguisher Trades' A. 106
Firefighting 105
Fire Officers, Nat. A. of 180
Fireproofing 106
Fire Protection A., Industrial 106, 179
Fire Res. Stn. 106, 179
Flavouring Compound M.A. of G.B. 102
Food 95
Food M. Fed. 108
Food M. Industrial Group 108
Food Mfg. Industries Res. A., Br. 108
Food Producers, Nat. A. of Frozen 108
Food Standards Committee, Nat. A. of Sciences, Washington 107
Food Standards Committee of the Ministry of Food 107
Foodstuffs additives 107
Founders', A. of Bronze and Brass 110
Founders' A., Light Metal 110
Foundry Craft Training Centre, Nat. 110
Foundrymen, I. of Br. 110

Foundry preparations 109
Foundry Trades Equipment and Supplies A. 109
Fuel additives 111
Fuel, I. of 82, 112
Fulmer Res. I. 161
Fungicides 123

Gas, North Sea 16
Gases, industrial 12
Gelatin and Glue Res. A. 94
Gelatins, glues 93
Glue and Gelatin M., Fed. of 94
Glycerine Producers' A., U.K. 85
Grants 52, 57
Greases 112

Haber–Bosch process 9, 11
Higher National Certificate 54
Horticultural Res. I., Scottish 104
Horticultural Soc., R. 105
Horticultural Soc., R. Caledonian 105
Horticultural Trades A. 104
Horticulture 92
Hosiery Dyers and Finishers, Midland 143
Hydrochloric acid 11

Industrial liaison ffiocer 168
Industrial Revolution 5
Industrial Safety (Personal Equipment) M.A. 176
Information retrieval 197
Information scientist 42, 153
Information Scientists, I. of 88
Inorganic chemicals 11–12
Instrumentation 31, 198
International Res. and Development Co. Ltd. 161
Ironfounders' A., Br. 110
Ironfounders' A., Malleable 110
Ironfounders' A., Nat. and Midland 110
Ironfounders' A., Scottish 110
Ironfounders' Nat. Confederation 110
Ironfounders', Nat. Fed. of Engineering and General 110
Ironfounding Employers' Fed., Nat. 110
Ironfoundry Associations, Council of 110
Iron and Steel I. 116
Isolates 100
Isotopes 182

John Innes I. 104
Joint Negotiating Machinery 86

Laboratories 34
  analytical 39
  research 33
  technical service 35
Laboratory chemicals 113
Laboratory technicians 51, 55
Labour, Ministry of 85
Lacquers 116
Latex Foam M.A., Br. 135
Laundry 95
Lavoisier, Antoine 5
Leather chemicals 140
Leather Fed., Br. 141
Leather I. 141
Leather M. Res. A., Br. 141
Leather Producers' A. for England, Scotland and Wales 141
Leather Trades' Chemists, Soc. of 141
Levinstein, Ivan 8
Library A. 42, 66, 88
Library of Congress 69
Library, Nat. Lending 69
Library of Science and Invention, Nat. Reference 74, 149
Literature survey 153
Little, Arthur D., Res. I. 161
Lubricants 111, 113
Lubricants A., Scottish 113
Lubricating Oil and Grease Fed., Nat. 111, 113

Lubrication Engineers, American Soc. of 113

Management, Br. I. of 87
Man-made fibres 12
Manufacturing Chemists, A. of 84, 127
Marketing and Sales Management, I. of 88
Marketing Res., European A. for Industrial 38
Mathematics and Mathematicians 3, 31, 34, 40, 57
Mechanical engineering 16
Mechanical Engineers, In. of 81
Medicine 3
Mergers 9, 10
Metal Finishing A. 115
Metal Finishing, I. of 116
Metal Finishing Suppliers' A. 116
Metal Information Bureau 116
Metallurgy 92
Metallurgical Soc. of London 116
Metal treatment 114
Metals, I. of 116
Mycological Soc., Br. 124

National Certificate 50, 54
NEWTON, ISAAC 4
NIMEXE 27
Nitrogen 9
Non-destructive Testing Soc. of G.B. 178
North Sea gas 16

Occupational Medicine, Soc. of 177
Oil additives 111
Oil and Colour Chemists' A. 82, 119, 130
Oil and Colour Students' A., Borough 119
Optical whitening agents 95
Organic chemicals 8, 12
  heavy 15

Paint A., Nat. Marine 119
Paint Colour and Varnish M., Res. A. of 119, 130
Paint Industries Club 120
Paint Makers' A. of G.B. 119
Paint M., Scottish A. of 119
Paint M.A., Bristol and the West 119
Paints 116
Paint Trade Benevolent Fund 120
Paint Varnish and Lacquer Club, Birmingham 119
Paper 92
Patent Agents, Chartered I. of 43
Patents 146
  abstracts 149
Patternmakers, Nat. Soc. of Master 109
Perfumery, Cosmetic and Detergent Industries, Br. 100
Perfumes 99
Periodicals *see separate index*
PERKIN, WILLIAM HENRY 8
Personnel Management, I. of 40, 87
Pest Control A., Industrial 123
Pest control products 121
  fungicides 123
  insecticides 124
  weedkillers 124
Pesticides Group, S.C.I. 123
Petroleum Information Bureau 112
Petroleum, I. of 67, 112
Petroleum, source of chemicals 15
Pharmaceutical Industry, A. of the Br. 84, 126
Pharmaceuticals 13, 125
Pharmaceutical Soc. of G.B. 127
Phosphorus 11
Photographers, I. of Incorporated 128
Photographic chemicals 127
Photographic Soc. of G.B., R. 128
Physical Laboratory, Nat. 157
Physical Soc. 69
Physicists 3, 31, 34, 57
Physics, I. of 69
Pigments 12, 128
Plant projects in U.K. 28

Plant safety officers 178
Plastic Cable Makers, A. of 131
Plastic Houseware M.A. 132
Plastic Line M. and Contractors, A. of 131
Plasticizers 132
Plastics 2, 9, 14, 130
Plastics and Allied Trades Protection A. 131
Plastics Fed., Br. 85, 131
Plastics I. 82, 132
Poison 180
Poisons Control Centres, International 181
Poisons Information Service, Nat. 180
Polymers 15
Printing 120
Printing Ink M., Soc. of Br. 120–1
Printing inks 117, 120
Printing, Packaging and Allied Trades Res. A. 121
Propellants 102
Proprietary Articles Trade A. 127
Proprietary A. of G.B. 127
Protective Clothing 176
Protective Headwear M.A. 176
Public Relations, I. of 41
Purchasing Officers' A. 39

Qualifications 49
  chemists 50
  non-technical 57

Radioactivity 182
Radiochemicals Centre 88, 182
Reagents 113
Refrigerants 132
Refrigeration A., Br. 133
Refrigeration, I. of 134
Research
  chemical engineering 170
  government supported 171
Research associations, industrial, listed 162–5
Research stations, government, listed 166–8
Resins 139
  acrylic 137
  amino 137
  epoxy 93, 131, 137
  phenolic 137
  polyamide 137
  vinyl 137
Rothamsted Experimental Stn. 104
Royal Society 5
Rubber and Allied M., Fed. of Br. 135
Rubber chemicals 134
Rubber Industry, In. of the 82, 136
Rubber latex 93
Rubber M.A., Br. 135
Rubber Mfg. Employers' A. 135
Rubber and Plastics M.A. 135
Rubber and Plastics M.A., Br. Cellular 131, 135
Rubber and Plastics M.A., Br. Seamless 132, 135
Rubber and Plastics Res. A. of G.B. 132, 136
Rubber Proofers' A. 135
Rubber and Resin Adhesives M.A., Br. 94
Rubber, synthetic 140

Safeguarding of Industries Act 9
Safety
  electrical 175
  measures 174, 182
Safety Council, Br. 175
Safety in Mines Res. Establishment 179
Sandwich course 49, 51
Scholarships *see* Grants
School leavers 40, 44, 50
Science, Nat. Fed. of (Washington) 67
Science Research Council 58
Scientific Instrument M. Res. A. 183
Scientific and Technical Information, Office for (OSTI) 43
Scientific and Technical Information, I. of (Moscow) 67

Scientific Workers, A. of 86
Silicones 136
Size of companies 29
Small packs 113
Soap, Candle and Edible Fat Trades Employers' Fed. 138
Soap Makers' A. 96, 138
Soap Makers, Soc. of Br. 96, 138
Soaps 137
Soda ash (alkali) 5, 11
Soil A. 105
Soil Res., Macauley I. for 104
Soils 102
Soil Science, Br. Soc. of 105
Solvents 138
Specialized industries 92
Standard Industrial Classification
  U.K. 17
  U.S. 19
Standards In., Br. 84
Statisticians, A. of Incorporated 57
Statistics 16, 20
  Central Statistical Office 17
  Statisticians 34
Steel Castings Res. A., Br. 110
Sulphate of Ammonia Fed., Br. 104
Sulphuric acid 6, 11
  measure of industrialization 7
Sulphuric Acid A., Nat. 85
Superphosphate M.A. 104
Surface-active Agents, Br. Nat. Committee on 96
Surface coatings 116
Surfactants 95

Tanners' A., Br. Kid 141
Tanners' A., Master 141
Tanners' A., Oak Bark 141
Tanners' Fed., N.W. 141
Tanning 140
Tanning Extract M.A., Br. 141
Technical service 35
Technical Services, Office of 67
Technological Awards, Nat. Council for 54
Technological courses 92
Technology, Diploma of 49, 50, 54
Tetra-ethyl lead 111
Textile Finishing Trades A. 142
Textile I. 100, 143
Textile M.A., U.K. 142
Textile auxiliaries 141
Textiles 92, 94
Theses 157
Timber Res. and Development A. 123
Time off 33, 51
Trade Associations 11, 83
Trade, Board of 83, 84

Universities 50, 92

INDEX
Book Titles and Periodicals

Accidents: how they happen and how to prevent them 175
Adhesion 93
Adhesion and Adhesives 93, 94
Adhesives, Concise Guide to Structural 93
Adhesives Directory 93
Adhesives Guide 94
Adhesives, Handbook of 93
Adhesives, Technology of 93
Aerosol News, Manufacturing Chemist and 126
Aerosols, Science and Technology of 133
Agricultural Chemicals 103, 122
Agricultural History Review 103
Agricultural Science, J. of 103
Agriculture 103
Aids to Readers 74
Analogue Computing for Beginners 187
Analogue and Hybrid Computers, Electronic 187
Analysis, Chemical 114
Analytical Chemistry, Treatise on 114
Analytical Methods for Pesticides, Plant Growth Regulators and Food Additives 107
Animal Husbandry, Basic 143
Animal Husbandry, Practical 143
Annual Abstract of Statistics 25
Anti-corrosion Methods and Materials 115
Aslib Directory 160
Automatic Data Processing 197
Automatic Digital Calculators 197
Automation and Computing 200
Award of Membership 54
Awards Conferred, Memorandum on 54

Bacteriology and Immunity, Toplay and Wilson's Principles of 97
BEILSTEIN 60, 151
Bibliographic Index 75
Bibliographie der Bibliographien Internationale 76
Bibliographique, Sources du Travail 76
Bibliography of Bibliographies, World 76
Biochemical J. 69, 81
Biochemistry, Careers in 57
Biochemists, Training of 57
Biology as a Career 57
Board of Trade Business Monitor Series 24
Board of Trade J. 21, 76
Bulletin de la Société Chimique de France 71
Bulletin of the Chemical Society of Japan 74
Bulletin Signaletique 67
Buyer's Guide, Chemical Week 76

Care, Handling and Disposal of Dangerous Chemicals 177
Careers, Industry and 46
Cellulosics 137
Census of Plants and Employees, Chemical Process Industries 20
Census of Production 24
Chemical Abstracts 66, 67

Chemical Age 28, 69
Chemical Age, This 3
Chemical Business Handbook 42
Chemical Dictionary, Condensed 60, 156, 177
Chemical Encyclopedia 60
Chemical Engineer 69, 81
Chemical Engineering, British 67, 69
Chemical Engineering, Canadian J. of 71
Chemical Engineering Data Book 156
Chemical Engineering, International 70
Chemical Engineering (Japan) 74
Chemical and Engineering News 32, 46, 67
Chemical Engineering Progress (U.S.) 70
Chemical Engineering Science 69
Chemical Engineering, a Career 56
Chemical Engineering, Education and Training in 55
Chemical Engineering, Introduction to 32
Chemical Engineers, Computational Techniques for 200
Chemical Engineers' Handbook 33
Chemical Enterprise, Administration of 38
Chemical Guide to the U.S. 20, 30
Chemical Industry 1965/6 OECD 26
Chemical Industry, A Career for You 30, 45
Chemical Industry Directory and Who's Who 70, 76, 80, 90
Chemical Industry, File of Corporate Diagrams 30
Chemical Industry, History of Modern British 10, 45
Chemical Industry, The 5
Chemical Industry, The Earliest 5
Chemical Literature, Use of 75, 151
Chemical Manufacturers and Soapmakers' Directory 70
Chemicals and their Manufacturers, British 76, 83
Chemical Market Abstracts 21
Chemical Market Research in Practice 36
Chemical Operators, Scheme of Training for Qualified 56
Chemical Plant, British 76, 84, 198
Chemical and Process Engineering 69
Chemical Process Industries 33
Chemical Process Industries, Facts and Figures for 71
Chemical Processing 69
Chemical Publications, Mellon's 151
Chemical Society of Japan, J. of 74
Chemical Statistics Directory No. 3 20
Chemical Technology, KIRK AND OTHMER 60
Chemical Titles 66
Chemical Week 70
Chemical Worker 70
Chemicals, A Career in 56
Chemicals, Additives and Drugs 88
Chemicals, British, and their Manufacturers 45
Chemicals and Drugs, Merck Index of 151
Chemie, Angewandte 67, 71
Chemie-Ingenieur-Technik 71
Chemische Industrie 71
Chemisches Zentralblatt 66, 67, 149, 150, 160
Chemist and Druggist 126
Chemistry, Annual Reports on the Progress of 82, 157
Chemistry, Applied, J. of 69
Chemistry, Applied, Reports on the Progress of 70
Chemistry, Bibliography of Reviews of 157
Chemistry and Chemical Industry (Japan) 74
Chemistry Films, Index of 76
Chemistry, How to Find Out in 3, 49, 60, 69, 146
Chemistry and Industry 69

Chemistry and Industry Buyers' Guide 70
Chemistry, Teach Yourself 31
Chemistry, Thorpe's Dictionary of Applied 60
Chemistry, Understanding 31
Chimico, Guida Bibliographia Internazionale 75
Chimie, Annales de 71
Chimie et Industrie 71
Cleaning and Maintenance 95, 97
Cobalt 115
Colour Index, The 98, 143
Computation for Chemical Engineers, Digital 200
Computer Applications in Commerce and Industry, A Select Bibliography on 200
Computer, Choosing a 197
Computer Control of Industrial Processes 200
Computer Design, Digital 188
Computer Fundamentals, Digital 188
Computer Languages, Dictionary for 193
Computer, Living with a 197
Computer Programming Fundamentals 193
Computer Programming Handbook 193
Computer Programming for Science and Engineering 193
Computer Technology, Analogue and Digital 187
Computers, Arithmetic of 192
Computers in Britain 197
Computers, Understanding Digital 188
Consultants in Chemistry, Directory of Independent 76, 80, 160
Control 201
Copper 115
Cost Engineering in Chemical Industry, Fundamentals of 33
Crop Protection, Scientific Principals of 122
Crops, World 122
Current Chemical Papers 66
Dangerous Properties of Industrial Materials 177
Data Processing 201
Data Processing J. 201
Data Processing Magazine 201
DDT and Persistent Insecticides 125
Dermatitis, Industrial 176
Dictionary of Chemistry and Chemical Technology in Six Languages 156
Dictionary, The Concise Oxford 156
Diseases of Farm Crops 123
Diseases and Pests of Farm Crops, Recognition of 123
Disinfectants: their value and uses 97
Disinfection and Sterilization 97
Doctoral Dissertations 75
Druck Technik, Archiv für 121
Drugs, May's Chemistry of Synthetic 126
Drugs, Synthetic 126
Dust Diseases in Industry, Prevention and Control of 176
Dye Chemistry, Fundamental Processes of 98
Dyeing and Chemical Technology of Textile Fibres 98
Dyeing with Coal Tar Dyestuffs, Whitaker's 98
Dyeing, Manual of 98
Dyeing, Physical Chemistry of 98
Dyeing, Summary of Current Literature on Textiles and 98
Dyeing of Synthetic Fibres, Preparation and 142
Dyeing and Technology of Textile Fibres 142
Dyer, International 100
Dyers and Colourists, J. of Soc. oj 98
Dyes, Manufacture of Intermediates and 98
Dyes and Pigments, Chemistry of Synthetic 98, 129
Dyestuff Reporter, American 100, 142
Dyestuffs, Synthetic 98

Economic Trends 23
Electrochemical Soc. J. 115
Electronic Business Machines 40
Electronic Computers and their Business Applications 40
Electronic Office, The 40
Electroplating and Metal Finishing 115
Employment and Productivity Gazette 25
Encyclopaedia Britannica, The 156
Engineering Index Monthly Bulletin 66
Entomologist, The 125
Entomologists' Gazette 125
Entomologists' Monthly Magazine 125
Essential Oils, The 101
European Chemical News 74
Explosion Hazard from Flammable Dusts 179
Explosives 102
Explosives, Chemistry and Technology of 102
Explosives and Propellants, High 102
Eyes, Protection of the 176

Farm and Garden Contractor 104
Faster than Thought 185
Fertilizer Notebook, The Manure and 103
Fertilizer Statistics 103
Fertilizers 103
Fertilizers, Commercial 103
Fertilizers and Manures 103
Fire 106
Fireproofing of Fabrics 106
Fire Risk and Fire Extinction, Chemistry in Relation to 105
Flameproofing Textile Fabrics 106
Fluorocarbons 137
Food Additives, Analytical Methods for 107
Food and Agriculture, Handbook of 107
Food and Cosmetic Toxicology 108
Food Engineering 108
Food Manufacture 108
Food Processing and Marketing 108
Food Science and Technology 107
Food Trades Review 108
Foreign Trade (EEC) 27
Foundryman, The British 109
Foundry Practice 109
Foundry Practices 109
Foundry Trade J. 109
Fuel 111
Fuel Abstracts 82, 111
Fuel Technology, Elements of 111
Fungicide Handbook, Insecticide and 124
Further Education in England and Wales 51
Further Education for School Leavers 52

Gassing Casualties, Systems of Labels for 178
German/English Dictionary, Standard 156
Giant Brains 186
Grants Year Book 52, 58
Graphic Technology 121
Gravure 121
Grouping of Chemical Industries 18
Guide to Grants 57

High Vacuum Engineering, Handbook of 115
Housekeeping Competition 176
Hydrocarbon Compounds, Encyclopaedia of 156

I.C.I.: a Survey 10
Industrial Detergency 95
Industrial and Engineering Chemistry, 70
Industrial and Engineering Chemistry Chemical and Engineering Data 70
Industrial and Engineering Chemistry, Fundamentals 70

Industrial and Engineering Chemistry, Process Design and Development 70
Industrial and Engineering Chemistry, Product Research and Development 70
Industrial Finishing 115, 118
Industrial Finishing Equipment, An Introduction to 114
Industrial Research in Britain 34, 160, 161
Industrial Research, Theory and Practice of 34
Industrial Scientific Research, Organization of 34
Ink Maker, British 120
Insecticide and Fungicide Handbook 124
Insecticides, Organic 124
Insect Pests of Glass House Crops 124
Instrument Abstracts 198
Instrument Engineer 198
Instrument Manual 198
Instrument Soc. of America, Trans. and J. of 199
Instrument Technology 198
Instruments and Control Systems 198
Instruments Directory, British 198
International Critical Tables 156

Jahrverzeichnis der Deutschen Hochschulenschriften 75

Kauchuk i Rezina 74
Khimicheskaya Promyshennost 71
Kholodil'naya Tekhnika 71

Laboratory Administration 34
Laboratory Chemicals, Purification of 114
Laboratory Technicians and Assistants 51
Laboratory Techniques in Chemistry and Biochemistry 113
Lancet 126
Lead Abstracts 115
Leather 141
Leather, Chemistry and Technology of 140
Leather Directory 140
Leather Goods 141
Leather Manufacture, Chemistry of 140
Leather Manufacture, Modern Practice in 140
Leather Manufacture, Principles and Processes of Light 140
Leather Workers' Handbook 141
Leathers, Standard Handbook of Industrial 140
Literature Resources for Chemical Process Industries 75
Lubricants, Synthetic 112
Lubricating and Allied Oils 112
Lubricating Greases, Manufacture and Application 112
Lubrication Engineering 113
Lubrication Engineers, Trans. of American Soc. of 113
Lubrication, Principles of 112

Manpower in the Chemical Industry 26
Manufacturing Chemist and Aerosol News 126
Marking Containers 178
Mathematics, How to Find Out in 57
Medical Journal, British 126
Medical Supervision in the Chemical Industry 176
Medicine and Drugs, Current 126
Medicine and Surgery, Industrial 126
Metal Finishing Handbook 114
Metals, Chemical Surface Treatment of 114
Metals, Electrolytic and Chemical Polishing of 114
Metals, General 109
Metals, J. of 115
Metals, J. of the Institute of 115
Metals, Protective Coatings for 114

Metals, Trans. of American Soc. for 115
Monthly Digest of Statistics 23

Non-metallic Coatings, Technology of 117

Oil Chemists' Society, J. of the American 119
Oil and Colour Chemists' Association, J. of 118
Oil, Paint and Drug Reporter 21, 118
Opportunities for Girls and Women in Science and Technology 46
Opportunities for Graduates 46
Opportunities for Qualified Men 46
Organic Chemistry, Elsevier's Encyclopaedia of 151
Organo–Metallic compounds, Chemistry of 136
Organo–Metallic compounds, Industrial Applications of the 137
Overseas Trade Accounts of U.K. 25

Paint Chemists' Handbook 118
Paint, Oil and Colour J. 118
Paint Oil and Colour Year Book 118, 120, 129
Paint Technology 118
Paint Technology Manuals 117, 129
Paint Trade Manual of Raw Materials and Plant 118
Paint and Varnish Technology 117
Painters' Craft Science 118
Paper and Print 121
Papilloma of the Bladder in Chemical Industry 178
Patent Abridgments 148
Patents Classification Key and Index 148
Patents, Derwent Publications 150
Patents, How to Find Out about 146
Patents Journal 149
Patents Manual, Derwent 148
Perfumer and Cosmetics, American 101
Perfumery and Essential Oil Record 101
Perfumery Materials, Chemistry of 101
Perfumery, The Practice of Modern 101
Perfumery, Synthetics and Isolates 101
Perfumes, Cosmetics and Soaps 101
Perfumes and their Production 101
Periodica Chimica 69
Periodicals Directory, Ulrich's 67, 71
Periodicals, List Abstracted by Chemical Abstracts 69
Personnel Management Handbook 41
Pest Control 122
Pest Control, International 122
Pesticides Monitoring J. 122
Pests of Field Crops 124
Petroleum 111
Petroleum, J. of the Institute of 67
Petroleum Times 111
Pharmaceutical J. 126
Pharmacology, Basic Facts of 126
Pharmacology and Therapeutics, Introduction to 126
Pharmacology and Therapy, British J. of 126
Pharmacopeia, British 126
Photographer, The 128
Photographic Chemistry 128
Photographic Chemistry, A Text Book of 128
Photographic J. 128
Photographic Materials 128
Photographic Process, Theory of the 127
Photographic Science, J. of 128
Photography, Chemical Analysis in 127
Physics, How to Find Out in 74
Physics, J. of Applied 69
Pigments, Chemistry and Physics of Organic 129
Pigments, Dyestuffs and Lakes 129
Pigments, Manufacture of Lakes and Precipitated 129

Plant Diseases 124
Plant Protection, Practical 122
Plasticheskie Massy 71
Plasticizers 132
Plasticizers, Behaviour of 132
Plastics 131
Plastics Abstracts 131
Plastics, British 131
Plastics, Concise Guide to 130
Plastics, Gum 137
Plastics, Laminated 137
Plastics Materials, 130
Plastics, Modern 131
Plastics RAPRA Abstracts 131
Plastics, Scientific and Technological 130
Plastics in the Service of Man 130
Plastic Sheet Forming 137
Plastics Technology 131
Poisoning, Diagnosis and Treatment, Handbook of 182
Poisoning, Symptoms and Treatment of Acute 181
Poisons, Analytical Chemistry of Industrial 181
Poisons, Chemical Identification, Symptoms and Emergency Treatment 181
Poisons, their Isolation and Identification 181
Polyesters 137
Polyethylene 137
Polymer 131
Polymers, Physical Properties of 130
Polymer Science, J. of Applied 131
Polystyrene 137
Polyurethane 137
Postgraduate Awards (U.K.) 59
Pressurized Packaging (Aerosols) 133
Prices, Sources of Commodity 21
Print in Britain 121
Printer, The British 121
Printing Inks, Industrial 120
Printing Ink Manual 120
Printing Ink Technology 120
Printing and Litho Inks 120
Printing Technology 120
Printing Trades J. 120
Printing World 120
Process Control 200
Process Control, Techniques of 200
Process Instruments and Control Handbook 198
Professional and Learned Societies of G.B. 80
Propellant Chemistry 102
Propellant Chemistry, Advanced 102
Protective and Decorative Coatings 117, 129
Public Health 122
Public Relations, Handbook of 41
Purchasing for Industry and Public Undertakings 38

Radiology, British J. of 182
Recherche Scientifique, Centre National de la (*Bulletin*) 67
Referativnyi Zhurnal Khimiya 67
Refrigeration, Automatic 133
Refrigeration, Bibliographic Guide to 133
Refrigeration, Principles of 133
Research Associations, Careers in the Industrial 162
Research in British Universities and Colleges 168, 170
Research, Directory of Graduate (U.S.) 75
Resins and Allied Plastics, Synthetic 139
Resins, Chemistry of Synthetic 139
Resins, Polymers and 139
R.I.C. Training Guide 53, 59
R.I.C. Regulations for Admission to Licentiateship 53
R.I.C. Regulations for Admission to Membership 53
R.I.C. Study Guide for Graduate Membership Courses 53
Rubber and its Use 134
Rubber, Applied Science of 134
Rubber, British Compounding Ingredients for 134
Rubber Chemicals 134
Rubber Chemistry, Modern 134

Rubber, Compounding Ingredients for 134
Rubber Industry, History of 134
Rubber Industry, Trans. of the Institution of the 135
Rubber Journal 135
Rubber, Natural and Synthetic 140
Rubber and Plastics Age 135
Rubber and Plastics Testing 135
Rubber RAPRA Abstracts 135
Rubbers, Introduction to Natural and Synthetic 134, 140
Rubbers, Modern Synthetic 140
Rubber, Synthetic 140
Rubber Technology 136
Rubber Technology, Introduction to 136
Rubber World 135
Russian Accessions, Monthly list of 69

Safe Transport of Hazardous Chemicals 178
Safety and Accident Prevention in Chemical Operations 177
Safety, British J. of Industrial 175
Safety Bulletin, Industrial 175
Safety Circulars (CIA) 178
Safety, Code of Electrical 175
Safety Equipment, Industrial 176
Safety, Industrial 176
Safety in Inspection and Maintenance of Chemical Plant 176
Safety in Laboratories 184
Safety and Management 174
Safety Measures in Chemical Laboratories 184
Safety News 176
Safety Organization in Small Works 176
Safety Training, A Guide for the Chemical Industry 176
Sandwich Courses and Block Release Courses, List of 51
Sanitarian 122
Sanitary Chemicals 97
Scientific Encyclopedia, Van Nostrand 156
Scientific Instrument Directory 158
Scientific and Learned Societies of G.B. 90, 158
Scientific Research, Principles of 35
Scientific and Technical Conferences, Forthcoming International 79
Science and Technology, Guide to the World's Abstracting and Indexing Services in 67
Science and Technology Index, Applied (U.S.) 66
Scientists, Directory of British 158
Searching the Chemical Literature 75
Silicones 136
Silicones, Introduction to the Chemistry of the 136
Silicones and other Organic Silicon Compounds 136
Silicones and their Uses 136
Soap and Chemical Specialities 96, 138
Soap and Chemical Specialities, Blue Book of 137
Soap and Detergent Industry, The Modern 138
Soap Makers' Directory, Chemical Manufacturers and 137
Soap Manufacture 138
Soap, Perfumery and Cosmetics 95, 101, 138
Soil, Chemicals, Humus and the 103
Soil Fertility and Fertilizers 103
Soils, Farm 103
Solvents 139
Solvents, Handbook of 139
Solvents, Industrial 139
Solvents and Plasticizers, Technology of 138
Solvents, Source Book of Industrial 139
Soviet Dissertation Lists 75
Statistical Series Available, List of 21
Statistics, Monthly Digest of 23
Statistics Sources 21
Sterilization and Disinfection 97

Storage and Use of Highly Inflammable Liquids, Code for 178
Sunday Times 48
Surface Activity 95
Surface Activity and Detergency 95
Surface Coatings, Modern 117
Surface Coating Technology, Principles of 117
Surface Coatings, The Science of 117
Synthetic Detergents 95
Systems 201

Technical Dictionary, Chambers 156
Technical Services for Industry 168, 171
Technology Index, British 66
Textilberichte, Melliand 142
Textiles, Man-made 142
Textiles, Modern 142
Thèses et Écrits Académiques, Catalogue des 75
Theses, Index to 75, 168
Toxic Agents, Laboratory Handbook of 182, 184
Trade Associations and Professional Bodies of the U.K. 80, 83

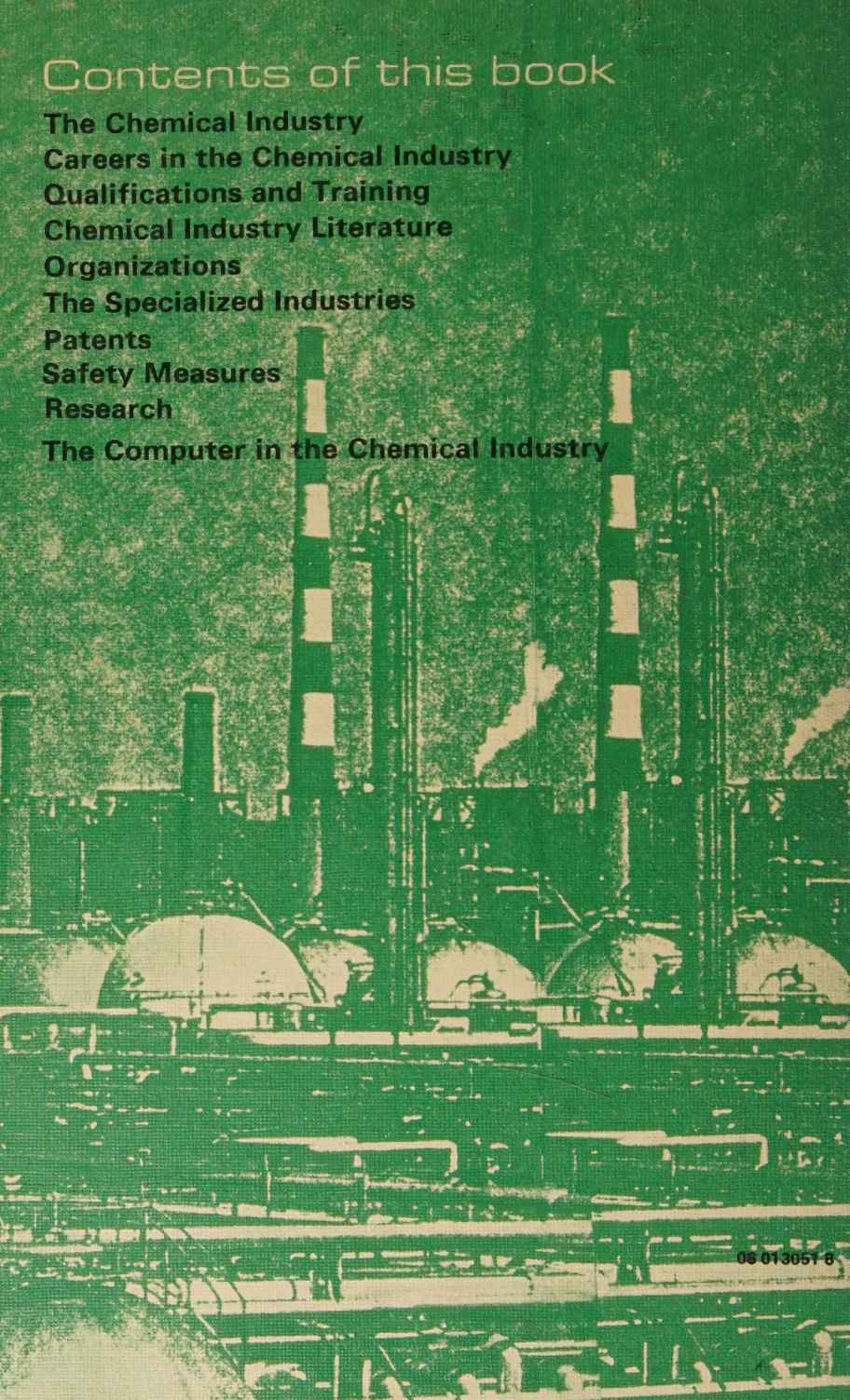
Union List of Serials in Libraries of U.S. and Canada 67

Veterinary Annual 144
Veterinary Bulletin 144
Veterinary Handbook, Baillière's 143
Veterinary Journal, British 144
Veterinary Medicine, International Encyclopedia 143
Veterinary Record 144
Veterinary Science, Research in 144
Veterinary Therapeutics, In roduction to 143

Water Engineers, J. of the Institution of 145
Water Supply, A text-book of 145
Water Treatment 145
Water and Water Engineering 145
Weed Control 124
Weed Control Handbook 124
Weeds 124
Where to Buy Everything Chemical 70
Wine and Food 109

Contents of this book

The Chemical Industry
Careers in the Chemical Industry
Qualifications and Training
Chemical Industry Literature
Organizations
The Specialized Industries
Patents
Safety Measures
Research
The Computer in the Chemical Industry



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